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CONTENTS

	Page
Frontispiece	692
Editor's Outlook	693
August Kekulé. L. Darmstaedter and R. E. Oesper	697
Chemical Training in Dutch Secondary Schools. P. E. Verkade	703
The Relation of Chemistry to Health and Disease. Paula M. Horn	711
The Relation of Chemistry to the Enrichment of Life. S. N. Alexander	717
Use of Potassium Ferrocyanide as a Confirmatory Test for Zinc. J. P. Mehlig	722
The Relation of Chemistry to Agriculture. Caryl Parker Haskins	723
The Relation of Chemistry to the Home. Catharine D. Barnsley	730
The Relation of Chemistry to National Defense. Culbert Rutenber	736
The Relation of Chemistry to the Development of the Cotton Industry. Gracia Greenhill	743
The Chemistry of Photography. III. Development of Negative and Positive Images. S. E. Sheppard	749
The Story of a Grain of Corn. II. Corn Products and Their Uses. W. R. Cathcart	758
The Training of Cereal Chemists. C. H. Bailey	766
Primary Cells—A Brief Historical Sketch. C. J. Brockman	770
A Device for Demonstrating Boyle's and Charles' Laws. F. Spencer Mortimer	781
Use of Working Drawings in a Laboratory Course in General Chemistry. Jesse E. Day	785
Correspondence	787

Chemical Digest:

Abstracts	793

Making the World Safe for Science; The Training of Teachers of General Science; The Need of a National Code of Ethics for Teachers; What's Wrong with the American High School? New Uses for Salt; Early Emotions and Early Reactions as Related to Mature Character; A Critique of the Present Status of Curriculum-Making; The Chemical Story of Local Anesthetics; Kekulé and His Hexagon; Environmental Chemistry in the Class-Room; The History of Glass Making—Optical Glass; Liquid Chlorine—Its Manufacture and Use; Manufacture of Yeast and Its Products; The Stimulation of Research in Pure Science Which Has Resulted from the Needs of Engineers and of Industry; Research in Colleges and Professional Schools; Agriculture and Modern Science; Research in Colleges and Professional Schools. II; Research Experience and Problems in a Small College; The Degree of Doctor of Philosophy; Chemistry and the Institute of Politics; Use of Ethylene in the Chemical Ripening of Fruits and Vegetables; The Relation of the Senior College and the Graduate School; Research on Nickel and Its Alloys; The Junior College Movement and Its Effect on the Reorganization of Science; The Evils of Standardized Education; The Contribution of Science to the Welfare of the Nation; An Accurate Method for the Determination of Phosphorus Pentoxide as Magnesium Ammonium Phosphate

Local Activities and Opportunities	801
Recent Books	803
A Few Moments with the Business Manager	807
June-July-August	808

PRELIMINARY PROGRAM FIFTH NATIONAL COLLOID SYMPOSIUM, COLLOID SECTION AMERICAN CHEMICAL SOCIETY, ANN ARBOR, MICHIGAN, JUNE 22, 23, 24, 1927

HARRY B. WEISER, *Chairman* FLOYD BARTELL, *Secretary*

H. R. Kruyt, "Unity and the Theory of Colloids;" W. D. Bancroft and R. L. Neugent, "Synthetic Kidneys;" F. E. Bartell and H. J. Osterhoff, "The Measurement of Adhesion Tension of Solid-Liquid Systems;" W. Blum, "Application of Colloid Chemistry to the Electrodeposition of Metals;" G. G. Brown and C. C. DeWitt, "The Relation of Colloidal Ferric Hydroxide to the Bond in Molding Sands;" James Craik, "The Cellulose Nitrates;" A. L. Ferguson, "The Chemistry of Body Processes; The Nature of the Action between Gelatine and Electrolytes;" R. A. Gortnor, W. F. Hoffman and W. B. Sinclair, "Proteins and the Lyotropic Series;" W. D. Harkins, "The Stability of Emulsions, Monomolecular and Polymolecular Films, Adsorption, and the Energy and Entropy of Surface;" H. N. Holmes and R. N. Maxson, "The Hydration of Soaps;" E. O. Kramer, "The Influence of Electrical Charge on the Sedimentation of Colloidal Suspensions;" L. Michaelis, "Investigation on Molecular Sieve Membranes;" E. J. Miller, "Adsorption from Solution by Ash-Free Adsorbent Charcoals;" Wm. Robinson, "Relation of Hydrophillic Colloids to Winter Hardiness in Insects;" C. H. Saylor, "Adsorption and Crystal Form;" A. J. Stamm, "Effects of Electrolytes and Electroendosmose through Wood Membranes;" H. B. Weiser and E. E. Porter, "The Physical Chemistry of Color Lake Formation;" A. H. White, "Colloid Properties of Hydrated Portland Cement."

Plasticity Symposium

E. C. Bingham, "Colloid Types;" F. L. Browne and Don Brouse, "The Consistency of Casein Glue;" P. M. Giesey and S. H. Arzoomanian, "A New Rapid Extrusive Type of Plastometer;" H. E. Phipps, "The Falling Sphere Viscosimeter and Plasticity Measurements;" S. E. Sheppard and E. K. Carver, "Plasticity and Solvation of Cellulose Esters;" J. K. Speicher and G. H. Pfeiffer, "The Falling Ball Method for the Measurement of Apparent Viscosity of Nitrocellulose Solutions."

DETROIT MEETING OF THE A. C. S. DIVISION OF CHEMICAL EDUCATION

Tentative plans for the fall meeting of the Division of Chemical Education are already taking shape. At present these plans include a symposium on the popularization of chemistry, an inspection trip to East Lansing to inspect the new chemistry laboratory of Michigan State College and three half-day sessions devoted to the presentation of miscellaneous papers. Dr. R. A. Baker, secretary of the Division, announces that no papers can be included in the program unless abstracts thereof reach his office, Bowne Hall, Syracuse University, Syracuse, N. Y., by July 15th.

O. E. Madison of Detroit has just been appointed Assistant Secretary of the Division for the Detroit meeting. He will aid in the arrangement of the local details of the program.

Friedrich August Kekulé

EDITOR'S OUTLOOK

The Prize Essay Contest

AS OUR May issue went to press we received notification that the college and university freshman prize-winners in the American Chemical Society prize essay contest had been selected. Time permitted only the insertion of an announcement to that effect, together with the names of the winners. In this number we publish the essays themselves.

As most of our readers undoubtedly know, the annual prize essay contests are made possible through the generosity of Mr. and Mrs. Francis P. Garvan, who have donated the awards in memory of their daughter, Patricia. It is, of course, impossible to estimate the total effect which these competitions have already had upon the dissemination of chemical information in this country. No doubt their influence is cumulative and will grow as time goes on.

However, we do know that thousands of students have thus been led to inform themselves of the contributions which chemistry has made and is making to our material civilization. The Prize Essay Committee estimates that approximately six thousand high-school manuscripts were actually submitted for consideration to various state and territorial sub-committees this year. This takes no account of the number prepared but eliminated by teachers and principals. In the colleges, also, it is difficult to determine the actual number of participants for many institutions submit but a small percentage of the number of papers written. At any rate it is apparent that the grand total must be surprisingly large. Nor does the sphere of influence of these competitions end with the contestants themselves. Doubtless much of the literature employed as source material by the students finds its way into the family circle and makes some impression there. At least we may confidently surmise that few homes which harbor hopeful essayists escape a hearing of the completed effort.

In general, it may be said that all contests of this nature make their strongest appeal to the superior student—to the boy or girl who has some cause to feel that his or her efforts may be crowned with more than average success. If one can place any dependence in the laws of heredity it is reasonable to suppose that the majority of such students come from homes of higher-than-average intelligence—from families which perhaps exert some small degree of influence in their respective communities. In view of these considerations it is evident that the essay competitions possess potentialities like unto the leaven of Biblical allusion.

Many teachers have found that they can profitably incorporate the essay contest into their work either as a special project for their more

promising students or as a regular part of the curriculum calculated to supplement and broaden the more formal portions of the course. Where the latter plan is employed it is true that many students do not enter into the work in a competitive spirit, but that, after all, is not the important thing. The end desired is that as many as possible may be stimulated to do the supplementary reading which supplies the general knowledge of things chemical that the teacher can spend all too little time in imparting in the class-room.

Altogether the Prize Essay Committee has every reason to conclude, as it did in its recent report, that "the results appear to justify the expenditure of time, money and effort involved in the contest."

The Committee also reports that Mr. and Mrs. Garvan have offered to sponsor a prize essay contest for the academic year 1927–28 along substantially the same lines as the previous contests, the principal change being in the contest for college and university freshmen. Next year the prizes in this class will be allotted according to the plan which prevailed in the normal schools and teachers' colleges this year. In each of the six groups of subjects there will be three prizes of $500, $300 and $200, respectively, instead of one prize of $1000. It is believed that this distribution of prizes will contribute toward greater interest on the part of the students.

Colloid Symposium

THE Fifth National Colloid Symposium will take place at the University of Michigan, June 22nd to 24th. During the past four years the Colloid Symposia have firmly established themselves as important annual events in the chemical world and have undoubtedly done much to stimulate the present widespread and growing interest which American chemists are taking in this branch of the science. The Symposium monographs have been from the first indispensable to the library of every colloid and general chemist and valuable additions to that of the industrial man.

So apparent has the need for a permanent organization of colloid chemists become that during the past year a Colloid Section of the American Chemical Society has been formed. The officers of the section, together with the Colloid Committee of the National Research Council are sponsoring this year's symposium.

As in former years, a distinguished foreign investigator has been invited to attend as guest of honor. Professor Kruyt of the University of Utrecht, Holland, will be present at the fifth symposium in that capacity and will deliver a paper on "Unity and the Theory of Colloids." The preliminary program giving the names of other authors and titles of their papers is published on page 690 of this issue.

A. C. S. Institute of Chemistry

THE Institute of Chemistry of the American Chemical Society to be held at Pennsylvania State College, July 4th to 30th, will follow a program which offers the teacher an excellent opportunity to enjoy a pleasant and highly profitable vacation period. The primary purpose of the Institute is "to offer a series of lectures whereby those in attendance may be brought quickly up-to-date in fields both within and outside their own specialties, and to afford facilities for teachers to acquire the latest information in chemical science as well as to benefit from the contacts with the industrial and consulting chemists."

No chemist can help but regret the limitations imposed upon his general knowledge of the science by the necessity for specialized activity and study. The teacher, however, by the very nature of his calling is made to feel such limitations more keenly and must combat them more vigorously than the man in any other line of work. To him the inability to keep up with the procession spells eventual professional death, slow perhaps, but ultimately certain. Such a series of general lectures as that scheduled for the Institute is, therefore, adapted to the fulfilment of a very definite and wide-spread need.

These lectures, which will take place at eleven o'clock every morning except Saturday, have been arranged on the conference plan. The topics will be presented first from the point of view of pure science with a review of recent advances and a presentation of the present status. The applications of the new principles in various industries and in other sciences will then be presented by speakers from the industries and allied sciences, with ample opportunity for general discussion. A question box for written questions will be an important feature.

The schedule of conferences is published on page 780 of this issue, so that those who are unable to attend the entire session can select the subjects which are of greatest interest to them.

The evening lectures will follow a more popular trend and will fall into two series; (1) popular lectures in science for those who are not professional chemists, and (2) "Chemistry in World Affairs," a series of addresses by chemists and men in public life. While designed to interest and inform the layman, these lectures will be equally interesting to the chemist and teacher of chemistry.

In addition, those who so desire may arrange to take one or two intensive courses in almost any branch of chemistry. High-school teachers will have an opportunity to observe the elementary courses conducted by well-known teachers and authors. Prof. Wilhelm Segerblom will conduct a course in the teaching of high-school chemistry.

Recreational facilities have not been overlooked and every opportunity will be afforded for pleasant and leisurely association among the members

of the Institute. The latter prospect is one the value of which can hardly be over-estimated.

Final programs and all details can be obtained from Dr. G. L. Wendt of Pennsylvania State College.

Milestones of Science

IN THE short space which has elapsed since the appearance of our last issue scientific history has been made. A new long-distance, non-stop flight record has been established and has been surpassed within a period of weeks. Twice within that time the long jump between the continent of North America and the mainland of Europe has been successfully attempted. Thus the aviator's dream, which was partially accomplished by John Alcock and Arthur W. Brown in 1919 in their flight from Newfoundland to Ireland, has been entirely fulfilled. Already we hear talk of a trans-Atlantic air mail and speculations on the possibility of a non-stop round-the-world flight.

Strictly speaking, no spectacular contribution has been made to the theory or practice of aerial navigation. Yet such feats as these are the dramatic incidents which constitute the milestones of history and mark the progress of underlying activities and influences.

Without detracting in the least from the credit due the aviators for their skill and bravery or attempting to reflect any of the glory which is so justly theirs upon others, it is possible to point out that their achievements were made possible through the untiring, unromantic labor, and research of men whose names may never be known to fame. The fliers themselves are the first to assert as much. Although not publicly acclaimed, the engineers and designers who devised the planes and, back of them, the chemists who made possible the materials necessary to their construction, may take honest pride in the demonstrated effectiveness of their efforts.

AUGUST KEKULÉ

LUDWIG DARMSTAEDTER, PRUSSIAN STATE LIBRARY, BERLIN, AND RALPH E. OESPER, UNIVERSITY OF CINCINNATI, CINCINNATI, OHIO

The development of more exact methods of determining atomic and molecular weights led, during the fifties of the nineteenth century, to the recognition of the fact that the atoms of the elements exhibited definite valencies. The halogens, for example, were considered to be univalent because one atom of any of them combined with or replaced one atom of hydrogen, the unit of valency. Sulfur and oxygen were held to be bivalent; nitrogen and arsenic, trivalent, and so on. The announcement of the quadrivalence of carbon, a logical consequence of the application of this doctrine is largely due to Kekulé, who, in 1858, wrote: "If we consider the simplest compounds of carbon, it appears that the quantity of this element which is considered by chemists as the smallest amount capable of existence—the atom—always binds four atoms of a monatomic or two of a diatomic element, so that the sum of the chemical units of the elements combined with one atom of carbon is always equal to four. We are thus led to the opinion that carbon is tetravalent." Couper, independently, came to the same conclusion, and Kolbe and Frankland also had recognized this fact, but the latter also held that the valency of an element may vary and this point was not conceded by Kekulé. He held, to the very last, that the valence of an element is as invariable as its atomic weight, and consequently Kekulé paid but little attention to the claims of his forerunners. In his later years, Kekulé became more indifferent to points of priority and said, "My views have grown out of those of my predecessors and are based on them. There is no such thing as absolute novelty in the matter."

FRIEDRICH AUGUST KEKULÉ

Kekulé's chief service in this consideration of the valence of carbon lay in his development of the theory of the chaining of polyatomic elements. He accounted for the unusual variety of carbon compounds on the basis of the ability of the atoms of this element to use part of their valencies for mutual satisfaction. "In the case of substances containing several

carbon atoms, we must assume that at least some of the atoms (of the other elements present) are held bound by the affinities of the carbon atoms, and that the latter are themselves linked together whereby a part of the affinity of the one carbon atom is necessarily tied by an equally large part of the affinity of the other." He derived the well-known $2n + 2$ value, as the saturation capacity of a chain containing n atoms of carbon. The mutual interchange of two affinities was shown to be a possibility, and compounds relatively poor in hydrogen, such as benzene and naphthalene, were referred to a more compact combination of the carbon atoms.

Friedrich August Kekulé, the real founder of the structure theory, was born in Darmstadt on September 7, 1829. The excellence of his work in mathematics and drawing at the local gymnasium influenced his father, a Hessian "Oberkriegsrath," to fit the boy for architecture. "Parents usually decide the life careers of their sons," said Kekulé many years later, and yet he was a glaring example of non-conformity. In 1847 he went to Giessen and attended courses in descriptive geometry, perspective, masonry, etc., but he was fascinated by Liebig's lectures and soon knew that chemistry was his heart's desire. The father died in August, 1847, and August's relatives, who opposed his going into chemistry, insisted that he spend at least one more semester at the Polytechnic School at Darmstadt, believing that the boy would outgrow this youthful whim. Their hopes were in vain, and in 1849 he returned to Giessen. His first research, a study of amyl sulfuric acid and its salts, was directed by Heinrich Will and he used this study as the basis for his doctorate thesis several years later. The degree was granted in July, 1852. In 1850 he declined Liebig's offer of an assistantship as his stepbrother, Karl Kekulé, generously provided the funds for a year of study in Paris. He attended Dumas' lectures and became the intimate friend of Gerhardt and Wurtz. He returned to Giessen for a short time and on Liebig's recommendation he became private assistant to Adolf von Planta, who had a laboratory in his Swiss chateau. He worked with his employer on nicotine and coniine, but he was not satisfied with this isolated position though it gave him plenty of time for reflection on theoretical topics, and in January he went to London as assistant to Stenhouse. Again he was fortunate in his intimate friendships, which this time included Williamson and Odling. This training under German, French, and English masters of chemical thought was of invaluable aid to Kekulé, ridding his mind of one-sided prejudices. "Originally a pupil of Liebig, I had become a pupil of Dumas, Gerhardt, and Williamson; I no longer belonged to any school.—Free yourselves from the spirit of the school, and you will then be capable of doing something of your own." While in London, he published a paper on thioacetic acid in which, for the first time, were indicated his ideas of the linking of atoms.

In 1856, Kekulé received a license to teach organic chemistry at Heidelberg. Bunsen dominated the chemical field at this university and as he had little interest in organic chemistry, he paid no attention to his young colleague or to the modest private laboratory that had been equipped from Kekulé's limited funds. Among the few students whom he could accommodate was Adolf von Baeyer who here made his study of organic arsenicals. (Baeyer once confessed that he should have preferred to devote himself to what later became physical chemistry, but he lacked the courage to buffet the current of organic chemistry, then in full flood.) Kekulé was busy with a study of mercury fulminate, but his most notable contribution during his stay at Heidelberg was the celebrated paper: "On the Constitution and Metamorphoses of Chemical Compounds and on the Chemical Nature of Carbon," in which he gave a full statement of his ideas on the linking of atoms—the foundation of modern constitutional formulas. The manuscript had been withheld from publication for more than a year as Kekulé was not certain that the time was right or the theory sufficiently matured. "Green fruit brings no profit to the grower; it damages the health of the eater; it is particularly bad for the young who are not able to distinguish between ripe and unripe."

Kekulé's work attracted international attention and, on the recommendation of Stas, the Belgian government, in 1858, offered the young German a professorship at Ghent. He accepted the call and a period of indefatigable activity began. Aided by his students, among whom were many of his countrymen, notably Hübner, Körner, Ladenburg, and Wichelhaus, he published a whole series of articles on organic acids; azo- and diazo-compounds; electrolysis of dibasic acids; the replacement of bromine by carboxyl in bromo-benzenes, etc. Three volumes of his "Lehrbuch der Organischen Chemie" appeared while he was at Ghent. The conclusion of the third volume was not published until 1880, but the work was never completed. Baeyer said: "Only such a man was capable of writing this 'Lehrbuch' which relegated all previous ones into an almost forgotten past." Japp wrote: "Here was a method of exposition immeasurably superior to any that had preceded it; and as a result every textbook of organic chemistry that has since appeared has shown more or less distinctly the influence of this remarkable work. The facts of organic chemistry appeared to group themselves spontaneously under the new system." Is it strange that the caustic Kolbe remarked that "it saved chemists the trouble of thinking?"

The epoch-making memoir "The Theory of the Constitution of Aromatic Compounds" was published in the Bulletin of the French Chemical Society in January, 1865. This contained the benzene theory and the logical conclusions and prophesies regarding the number of possible substitution derivatives of benzene; a discussion of the homologs of benzene and

their oxidation and substitution products. All of the predictions were verified and Japp was well justified in declaring: "This is the most brilliant piece of scientific prediction to be found in the whole range of organic chemistry. . . Three fourths of modern organic chemistry is directly or indirectly the product of this theory. . . . The industries of the coal-tar colors and the artificial therapeutic agents would be inconceivable without its inspiration and guidance." The phenomenal outgrowth of this theory is characterized by the great Kekulé celebration held in Berlin on March 11, 1890, to commemorate the twenty-fifth anniversary of its enunciation. The whole scientific world participated in this ceremony which was almost unique in that so short a period of years had sufficed to demonstrate the phenomenal theoretical and industrial usefulness of a single idea. In his address on that occasion, Kekulé stated that he felt that the chemical world, proud of its past and filled with hope for the future, was perforce holding this benzene celebration so soon because most theories do not last more than twenty-five years. He described the well-known vision of the "snake seizing hold of its own tail," but emphasized that this was only the culmination of years of deliberation over valence and linking of atoms.

> The benzene theory has been spoken of as a stroke of genius. I have often asked myself: "What is genius?" Genius is said to recognize truth without knowing the proof. It is also said that genius thinks by leaps and bounds. Gentlemen, the waking mind does not think by leaps. It has not the power to do so . . . The benzene theory did not appear as does a meteor in the skies. Any student of the history of science knows that no science has developed more steadily than has chemistry. We all stand on the shoulders of our predecessors; is it striking then that we have a wider range of vision than they? . . . If we easily arrive at the farthest points reached by our forerunners, travelling on paths only broken by them after overcoming innumerable difficulties, should we then deserve particular credit if we still have the power to penetrate a little farther into the unknown?

Kekulé's architectural training was of great value to him in visualizing the structural relations of compounds. He constructed numerous models to aid his students to grasp his ideas. He knew the limitations of graphic formulas and he emphasized the difficulty of representing double and triple bonds with models made in one plane only. "The imperfection of the earlier models may be obviated if the four units of affinity of the carbon atom, instead of being placed in one plane, radiate from the sphere representing the atom, in the direction of hexahedral axes so that they end in the faces of a tetrahedron. . . . A model of this description permits of the union of 1, 2, and 3 units of affinity and it seems to me does all a model can do." (1867) This tetrahedral model thus antedates van't Hoff's proposal by seven years, but as Baeyer pointed out: "Kekulé's models were smarter than their inventor and gave out more than he put into them." Kekulé believed that the four points of attraction of the

carbon atom were perfectly free to exchange positions and consequently each compound containing a carbon atom combined with four different elements could exist in only one position of equilibrium.

In 1867, Kekulé was called to Bonn. The laboratory designed by A. W. Hofmann was new, large, and well-equipped, and Kekulé's reputation as an incomparable teacher and lecturer soon attracted numerous brilliant pupils who collaborated with him in various important researches. He was so happy in these surroundings that in 1873 he declined to become Liebig's successor at Munich, but he had the pleasure of knowing that one of his pupils, Baeyer, was deemed worthy of occupying this desirable

Kekulé Monument in Front of the Chemical Institute at Bonn

professorship. During the next twenty years, Bonn was the scene of most interesting chemical vitality; Glaser, Bredt, Zincke, Wallach, Claisen, Anschütz, Bernthsen, van't Hoff, Thorpe, and others were proud to be numbered among the pupils of this genius and they strove to emulate his tireless activity. (The young Hohenzollern, who later became Wilhelm II, attended Kekulé's lectures during his university career at Bonn.) About 1876 his health began to fail, and his increasing deafness led him to shun even his intimate friends. There was no impairment of his mental powers, and up to the time of his death, July 13, 1896, he was complete master of recent progress in pure chemistry. The later years of his life were largely spent in repeating and criticizing work that had been pub-

lished in opposition to his theoretical views, and in practically every case, the outcome was the firmer establishment of Kekulé's ideas.

Kekulé was buried in the Poppelsdorf cemetery, in the outskirts of Bonn. In 1903 a bronze statue was erected to his memory in front of the chemical laboratory, and Glaser used the occasion of its unveiling to eulogize his teacher's contributions to chemical industry. Kekulé once said: "I have never worked for technical ends, always for science alone. I have always had the greatest interest in industrial matters, but I have never derived my interests from such sources." The theories proposed by this disciple of "pure" chemistry constitute the foundations of many industries, and the memory of "this intellect of incomparable power" will always constitute a valued portion of the heritage of the historians of all branches of our science.

Kekulé's achievements are perfect examples of the usefulness of the exercise of scientific imagination, but he was well aware of the limits and dangers of accepting dreams as "the substance of things hoped for, the evidence of things not seen." "Let us learn to dream, gentlemen, then perhaps we shall find the truth. . . . but let us beware of publishing our dreams before they have been put to the proof by the waking understanding."

Sweden Uses Peat as Coal Substitute. A new source of wealth has been found in the peat bogs of Sweden which heretofore have usually been regarded as so much waste land. Unlike the people of Ireland, the Swedish inhabitants have always had plenty of wood to use as household fuel, so that peat has only rarely been used for the purpose. On the other hand, Sweden lacks coal mines and in recent years many experiments have been performed with peat as substitute, and now the head of the Swedish peat industry, Lieutenant Herman Ekelund, declares that a peat powder can be produced by machinery, capable of creating any given degree of heat more cheaply than coal, and in more convenient form. With peat as a fuel, he claims that iron ore can be reduced in small electrical ovens. Compared with charcoal, the peat powder costs but one-half and if the iron thus produced is not of such high quality, it is better than that made with coke. With peat, temperature as high as 2200 degrees Centigrade have been attained.

An advantage of the new methods of exploiting the peat bogs is that the dug-over area is not left flooded, but can be worked as farmland after suitable drainage. Where farming is not advantageous, as in the northern parts of Sweden, where it is too cold, forests can be planted and regular lumber crops raised.—*Science Service*

Tests Show Iridium as Hardest Metal. Iridium, a metallic element in the same chemical group as platinum, and often used as the tip for fountain pens, is the hardest pure metal, according to tests recently made by A. Mallock, and announced in the scientific magazine, *Nature*. Molybdenum is the next hardest, with tungsten third. Nickel is the hardest of the common metals as it ranks fifth, the rare metal rhodium coming in fourth. These refer only to pure metallic elements, for some alloys, such as steel with a high percentage of carbon, rank higher than any.

The softest of the metals tested proved to be thallium, as it ranked number 24, lead being 23, and tin 22. Gold is 18, silver 15, palladium, which is in the same group as platinum and iridium, 14, aluminum 12, copper 11, and iron 10.—*Science Service*

CHEMICAL TRAINING IN DUTCH SECONDARY SCHOOLS

P. E. VERKADE, COMMERCIAL UNIVERSITY, ROTTERDAM, HOLLAND

In Holland, opportunities for pursuing a thorough study of chemistry are provided by the Government Universities of Leiden, Utrecht, and Groningen, by the Municipal University of Amsterdam, and by the Technical University at Delft. The Universities enable those students who have specialized in chemistry to take a degree, which may be regarded as equivalent to the degree of doctor of chemistry, although it is not known by that name, since the Dutch law designates all degrees in the domain of the exact sciences by the common denomination of "*doctor in de wis-en natuurkunde*" (doctor of mathematics and physics). The Technical University can confer the certificate of "*scheikundig ingenieur*" (chemical engineer), and subsequently the degree of "*doctor in de technische wetenschappen*" (doctor of technical sciences).

The privilege of attending lectures at the Universities or Technical University, and working in the laboratories, is open to anyone who satisfies the matriculation requirements and pays the required fee. To be qualified for going up for examinations, *i.e.*, for ultimately taking one's degree, one is, however, required to produce a final certificate from a *Gymnasium* or *Hoogere Burgerschool*. This requirement does not affect a number of exceptional cases (*e. g.*, foreign students) which, proportionately, do not play an appreciable part, and are left out of consideration here.

The Gymnasium

This institution, which is to be found in every town of any importance, has, for centuries past, supplied the proper preparation for the Universities. The pupils are admitted to the gymnasium at the age of about twelve years, after having completed a six-year course in an elementary school and stay there during another six years. At the end of the fourth a choice of two courses can be made, the essential difference between them being that part of the time which, in one section (gymnasium A), is devoted to the study of classical languages and history, is applied to the study of mathematics, physics, chemistry, etc., in the other (gymnasium B). Those who, later on, wish to take a degree in chemistry at one of the Universities will, as a rule, elect the gymnasium B. To be qualified for standing examinations at the Technical University, students coming from a gymnasium are even obliged to produce the "leaving certificate" of the gymnasium B.

The "Hoogere Burgerschool" (High School; Literally, "Secondary School for the Middle Classes")

This type of school, now far outnumbering the gymnasia, was called

into existence in 1863 for the education of those numerous citizens who, having left the elementary school, strive to acquire general knowledge, culture, and preparation for various industrial trades. Here, too, the pupils enter at the age of about twelve years; however, in this school their stay is confined to a period of only five years.

It was, therefore, not at all for the purpose of University preparatory training that these schools were created. From Table II it is apparent that the classical languages are not taught. Yet, there have always been a fair sprinkling of pupils who, having originally been sent to this type of school, for some reason or other, desired, on leaving it, to continue their studies in one of the Universities. In their cases this was only possible

TABLE I

THE GYMNASIUM CURRICULUM

	First year	Second year	Third year	Fourth year	Fifth year	Sixth year	Total
Greek	.	6	6	5	3	3	23
Latin	8	5	5	5	3	3	29
Dutch	4	2	2	2	2	2	14
French	5	3	2	2	2	2	16
German	.	3	2	2	2	2	11
English	.	.	3	3	2	2	10
History	3	3	3	3	2	3	18
Geography	2	3	2	1	1	.	9
Mathematics	4	3	3	3	5	5	23
Physics	.	.	2	2	3	3	10
Chemistry	.	.	.	2	3	4	9
Botany, Zoölogy	3	2	.	.	3	2	10
Gymnastics	2	2	2	2	2	2	12
Drawing	2	1	1	1	.	.	5

by submitting to a supplementary examination chiefly involving the classical languages, reading for which required some two years' study, as a rule. However, in 1918 this was changed (Limburg act). Nowadays, the fact that a pupil has obtained the leaving certificate of such a "high school" (as we may, for the sake of convenience, call it) renders it possible for him to study in a University, in the departments of medicine, mathematics, physics, chemistry, etc., *i. e.*, in those sciences for the pursuit of which the classical languages are not absolutely indispensable, and to submit to the examinations that are pertinent to these departments. For submitting to the examinations at the Technical University the owners of this leaving certificate have always been qualified.

The aggregate of knowledge which, on leaving the B section of the gymnasium or the high school, the pupils have acquired naturally defies survey within the scope of this paper. Yet the author has thought it

possible to convey an idea, though necessarily only a weak and superficial idea, of the extent of the subject-matter of tuition in either of these types of schools, by inserting Tables I and II. These tables show, for both schools, the number of hours that is weekly devoted to the various branches of tuition in each school year; they give at the same time some insight into the rank chemistry holds in the entire educational system.

Of course, in these two tables the whole educational system of the Dutch secondary schools is laid down in a condensed form and they, therefore, offer many possibilities for detailed discussions. However,

TABLE II

THE HIGH-SCHOOL CURRICULUM

	First year	Second year	Third year	Fourth year	Fifth year	Total
Dutch	4	3	3	2	2	14
French	5	4	3	2	2	16
German	4	3	3	2	2	14
English	.	4	3	2	2	11
History	3	2	2	2	2	11
Geography	3	3	2	1	1	10
Constitutional Law	.	.	1	1	.	2
Economics	.	.	.	.	2	2
Mathematics	6	6	6	4	4	26
Mechanics	.	.	.	2	2	4
Physics	.	.	4	3	3	10
Chemistry	.	.	.	4	4 plus 2	8 plus 2
Botany, Zoölogy	2	2	1	1	2	8
Cosmography	.	.	.	1	.	1
Gymnastics	3	3	3	2	2	13
Drawing	2	2	2	4	2	12

the author will confine himself to a few brief observations, which have, more or less, a direct bearing on our subject.

In either type of school a great many branches of tuition are taught, so that any pupil leaving one of the schools with a final certificate, having properly profited by the lessons given there, may be deemed to have acquired a considerable amount of sound general education. Yet, there is a danger lurking in this great number of branches of tuition: the pupils' attention is dispersed, often too much so! Expert opinion has it, all but universally, that the programs of these schools are overburdened. It is, indeed, a fact—and this applies particularly to the post-war period—that the results of this sort of instruction cannot be called favorable; the percentage of pupils who cannot pass through the entire school except with a great deal of continuous severe exertion, and who ultimately pass the final examination and obtain the leaving certificate, with very moderate

marks, is alarmingly high. Rather than to the gymnasium, this applies to the high school, where the number of branches of tuition that are dealt with is greater and where—as can be seen from Table II—only very little time is devoted to some of them.

Leaving aside the classical languages, which are not taught in the high schools, we find that the programs of these two types of school are very much akin, as regards the chief branches of tuition. It is not only the sum total of the hours devoted to each of these branches of tuition that is nearly equal (mathematics 23 and 26, physics 10 and 10, chemistry 9 and 8 hours, respectively, etc.), but that part of the subject matter of these sciences, which comes in for treatment in these two types of schools, shows a great resemblance as well. In connection with what has already been said it naturally follows from this that nearly all aspiring students have gone through an all but equal preparatory course of training, which goes to prove that University teaching may take it for granted that all the students possess rather the same knowledge of mathematics and natural science. There can be no doubt but that this constitutes a considerable advantage in University training.

The fact that in Dutch Universities students can nowadays pursue a study of chemistry without having any knowledge of the classical languages may be left undiscussed here. Elsewhere, for instance in the United States, the same state of things is met with. Among other things this often entails serious difficulties in the study of the history of chemistry, a branch of our discipline which should not be neglected. As a curiosity it may, in addition, be stated that the author has even heard some people object, for this very reason, to the universally adopted use of Greek characters in organic chemical nomenclature!

Both schools provide their pupils with such a knowledge of French, German and English as to enable them, in their college years, to read any book in one of these languages or to keep up with scientific literature that appears in these languages.

Both in the high school and in the B section of the gymnasium chemical training is initiated in the fourth year, the pupils being about fifteen years old, by then. In either of these schools, physics has already been taught in the preceding year. This is of material advantage. The chapters on liquids and on gases and part of the chapter on heat have already been gone through, so that the pupils are conversant with the law of the preservation of energy, Boyle's law, Charles' law (Gay-Lussac), have some notion of the molecular theory, know the principles of calorimetry, etc., all of which subjects are essential to a clean start in chemical training.

At the high school four hours a week are devoted to chemistry in the fourth and fifth years; in the B section of the gymnasium the number of hours amounts to two, three, and four in the fourth, fifth, and sixth years,

respectively. A precise delineation of the subject-matter that must be dealt with does not exist, a committee being engaged just now in compiling a delineation of the kind for the use of the high schools. We may confine ourselves to summarizing the subject-matter that comes in for treatment, as follows:

Inorganic Chemistry

Physical and chemical changes. Compounds and elements. Oxygen; Combustion phenomena. Laws of the perdurability of matter, of constant composition and of multiple proportions. Atomic theory. Chemical notation. Water and hydrogen. Oxidation and reduction. Chemical law of Gay-Lussac. Molecules; Avogadro's hypothesis. The principal metalloids, their occurrence and their compounds. Valence. Osmotic pressure; cryoscopy and ebullioscopy. Electrolysis; ionic theory. Chemical equilibrium. Heat of reaction. The principal metals, their ores, and their compounds. Important technological processes. Radio-activity. Periodic table.

Organic Chemistry

Introduction. Elementary analysis. The principal groups of organic compounds. Important technological processes.

With the exception of organic chemistry, which comes in for a somewhat more detailed treatment in Holland, the subject-matter can pretty well be compared with that which is contained in Smith's, "Intermediate Chemistry," Black and Conant's, "Practical Chemistry," and similar books. The author thinks he can convey some notion of the standard knowledge the pupils can attain by subjoining, in Table III, the tasks that were set for chemistry at last year's examination for the school-leaving certificate of the high schools, the tasks for the written part of this examination being the same for all the schools throughout the whole country. The time granted for elaborating these tasks is 3 hours.

TABLE III

The candidates have to answer the questions under *A* and those under *B;* further, those under *C* (*1*) or *C* (*2*) and those under *D* (*1*) or *D* (*2*).

A.

(*1*) 2.1 grams of a monovalent base, dissolved in 75 grams of water, give a lowering of the freezing point of 1.852°. The percentage dissociation of the base in this solution is 95. Calculate the atomic weight of the metal of this base.

H = 1; O = 16; molecular lowering of the freezing point of water (1 gram molecule in 100 gr. of water) is 19°C.

(*2*) If in the formation of carbon monoxide from carbon dioxide and carbon, heat is taken up, what is then the influence of temperature on the equilibrium: $CO_2 + C \rightleftharpoons 2CO$.

(*3*) A solution of potassium sulfide has a basic reaction and the smell of hydrogen sulfide. Explain this with the help of the ionic theory.

B.

(*1*) What products may be formed by the action of concentrated sulfuric acid on ethyl alcohol?

(*2*) How may nitroglycerol and nitrobenzene be prepared? How can it be proved that nitrobenzene is a nitro compound and nitroglycerol is not?

(*3*) How does sodium hydroxide react on: (*a*) sodium propionate; (*b*) phenol; (*c*) benzyl chloride; (*d*) a fat? State the conditions in each case.

C.

(*1*) How may chlorine be prepared in the laboratory? What is the action of chlorine on a solution of sodium sulfite?

How is the presence of a chloride in a solution demonstrated?

What is observed and what reactions take place if: (*a*) caustic soda is added to a solution of copper sulfate and the liquid is then heated; (*b*) tin is warmed with hydrochloric acid; (*c*) concentrated nitric acid is added to tin?

(*2*) How may hydrogen sulfide be prepared in the laboratory and how does this gas react on: (*a*) bromine water; (*b*) a solution of ferric chloride?

Describe the reaction of: (*a*) arsenic trioxide on caustic soda solution; (*b*) ammonium sulfide on a solution of aluminum sulfate?

How may cupric sulfate be converted into cupric chloride and this into cupric oxide?

D.

(*1*) How is a solution of sodium hydrogen sulfate obtained, if a buret, caustic soda solution, dilute sulfuric acid and a litmus solution are available?

What reactions occur on heating: (*a*) sodium bicarbonate; (*b*) mercuric nitrate; (*c*) ammonium chloride; (*d*) blue vitriol? How may a solution of ferric chloride be converted into a solution of ferrous chloride and into a solution of ferric sulfate?

(*2*) What conclusion must be drawn if the solution of a potassium salt on adding dilute hydrochloric acid gives evolution of: (*a*) carbon dioxide; (*b*) sulfur dioxide; (*c*) hydrogen sulfide; (*d*) nitrous fumes?

Concentrated sulfuric acid is poured over sodium bromide. Manganese dioxide is heated with dilute sulfuric acid and oxalic acid. Manganese dioxide is fused with potassium carbonate and potassium nitrate. What is observed in any of these three cases and to what reactions are the observations due?

It may be stated here that last year's task for chemistry was easier than usual and was considered by the candidates to be relatively easy. This is, indeed, borne out by the elaborations being very good, as is shown by Table IV. In this table are listed the marks which the present author awarded to ninety-one candidates examined by him, 1 being the lowest and 10 the highest mark that could be obtained.

This task would seem to be well-suited, indeed, to give an idea of the high standard of chemical training in the Dutch high schools. It shows that not only have the pupils mastered a substantial knowledge of facts (methods of preparation, reactions, etc.), but that they are also versed in problems of physical or general chemistry; it is the author's opinion that, in general, in Dutch schools too much value is set upon a large knowledge of chemical facts. Yet, these results must not, the author regrets having

to state, be overestimated. The pupils' knowledge is not always of a lasting nature. It has often been drubbed into their brains, for the mere sake of this school-leaving examination, and has evaporated, for a considerable part, a short time after the examination. In this connection it is significant that in the Universities and in the Technical University complaints are rather general, as regards the students' lack of knowledge of facts and especially of chemical insight after their matriculation. In justice to the pupils of other institutions it must be added that these complaints relate especially to the graduates of the high school, it being they who constitute the large majority of students. It has repeatedly appeared to the author that at the final examinations of the high schools many candidates could give no satisfactory answers to even easy questions and could not solve even simple problems, unless these questions or problems were worded in the manner to which they were accustomed or rather,

TABLE IV

DISTRIBUTION OF GRADES OF 91 CANDIDATES

Mark	Number of candidates
1	0
2	0
3	3
4	4
5	8
6	16
7	21
8	29
9	9
10	1

had been drilled in. It is very characteristic of this sort of training that, as little as half a year after they had passed the final examination of a high school, not one out of twelve students of the Commercial University in Rotterdam could unhesitatingly state how mercury reacts with nitric acid! The cause of these unsatisfactory results is undoubtedly to be found in the overburdening of the program of this type of school that has been mentioned already.

A contest may be said to be incessantly going on concerning the desirability of applying the heuristic method to chemical training. However, the number of teachers that have adopted this method has, so far, been small. All teachers, however, attach a great value to a substantial number of experiments performed during the lessons by themselves, with the incidental help of the laboratory steward, who is present at each school. In this respect chemical training, both in the high schools and in the gymnasia, is extremely well provided for.

In addition to the four weekly lessons in chemistry, of one hour's dura-

tion each, the fifth year of the high schools provides a course in practical chemistry of two hours a week. During that year the pupils are, therefore, obliged to make themselves acquainted, slightly though it may be, with the technic of our science. The work that is to be done in these practical courses is left to each separate teacher's discretion, and accordingly its character is widely divergent. As a rule, something will be done on the following subjects:

1. Some simple experiments on mixtures, compounds, solutions.
2. Preparation of some simple compounds (mostly of inorganic nature).
3. Simple reactions on the principal cations and anions.
4. Qualitative analysis of simple inorganic compounds, sometimes of a mixture of such compounds (in the latter case the cations in the mixture all belong to the same group, as a rule).
5. Simple acidimetric, oxidimetric, and iodometric determinations.

Some few teachers sometimes have a simple gravimetric determination performed by their pupils, *e. g.*, a determination of barium in barium chloride in the form of barium sulfate, in doing which, operations are commenced with a considerable quantity of the chloride so as to facilitate the experiment.

It is obvious that a practical course as described here does not in the least run parallel to the other lessons in chemistry and that it can hardly be said to be subservient to memorizing the things learned there. Accordingly, the value of this practical activity of the pupils is not set great store by, on the whole.

Besides the gymnasia and the high schools, the *Handelsscholen* (commercial schools) should be mentioned here. There are as yet two types of them, which, however, need not be discussed here any further, as in these schools chemistry—and, we may say, natural science in general—plays a far less important part than in the two types of schools that have been dealt with in this paper. Only the elementary principles of inorganic and organic chemistry are taught here. The leaving certificates of these schools do not qualify their holders for examinations in the Universities or in the Technical University.

Hair-Removing Chemical Found Dangerous. The use of depilatories may be attended by considerable danger. Drs. H. A. McGuigan and H. N. Ets of the University of Illinois Medical School have found that barium sulfide, the essential constituent of hair-removing preparations, will cause serious results in rabbits if a large enough area of the skin is covered with the chemical.

When a rabbit's ears were covered with a paste containing 50 per cent barium sulfide, enough was absorbed, said the experimenters, to kill the animal. Death is caused, they believe, by the formation of hydrogen sulfide which was detected in the animal's breath.—*Science Service*

THE RELATION OF CHEMISTRY TO HEALTH AND DISEASE*

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Since earliest times the highest objective of scientific research has been the prevention and cure of disease; the freedom of humanity from needless suffering and prolongation of the span of human life. Chemical research, more than any other, has been responsible for the control of various diseases and creation of health ideals. Sometimes diseases were subjected through the efforts of chemists alone, but more often better and quicker results were obtained by their coöperation with other research workers in pharmacy, anatomy, biology, and physics.[1] We, in the 20th century with our serums and antitoxins, supposedly sanitary environment, well-organized hospital service, wonderful operative technic and highly developed sciences, find it hard to realize the density of ignorance concerning the human body only a few centuries ago and how difficult and discouraging were the problems which confronted research workers at that time. The black death, smallpox and yellow fever, are to us only names on which hinge horrible tales of ages past, mystic and remote. In our living present they have no place or power. We hear of someone having had his leg amputated, of another having undergone a serious abdominal operation, of a woman having given birth to a child; as a matter of course, all are "getting along splendidly." We do not stop to think that not so many years ago reports might very well have been quite different; no anesthetic—in terrible pain, no disinfectant—infection has set in, delirium, and death the final verdict. Three tragic stories, and scores of hundreds like them. It is not that they cannot repeat themselves in our times, but that their likelihood has been so greatly reduced. It is then quite fitting that we should pause for a moment to pay tribute to that science, chemistry, and to those men, research chemists, who have made possible the banishment of many diseases and the relief of humanity from much misery and suffering. Here it is only possible for me to give a brief resumé of the knowledge chemistry has given us concerning our bodies together with several notable achievements which are towering monuments to the science and its faithful workers.

The important laws of chemical activity no doubt seem to us very elementary and simple, and truly they are when we consider their application and extent in more complicated fields of research. Yet we are filled with respect and reverence when we consider how laboriously, bit by bit, these were pieced together by dreams and work of centuries. Probably

* Prize-winning college essay, A. C. S. Prize Essay Contest, 1926–1927.

[1] Emery, Downey, Davis, Boynton, "Chemistry in Daily Life," p. 11; Wolfgang Pauli, "Physical Chemistry in Service of Medicine," p. 8; American Scientists, "Independence and Progress of American Medicine in the Age of Chemistry."

every college student knows that all life is chemical activity, the highest expression of the transformation of matter and energy; that every breath we draw, every motion we make, involves chemical combustion. The assimilation of our food, its proper utilization, its proper elimination, every single function of our body is dependent upon definite chemical processes.[2] That a single cell is the basis of all life. "The human body is built up of innumerable cells and depends upon cell secretion, cell excretion, cell multiplication for its life function. When the cells are in good working order the body is in health, but when the cells are unsound or abnormal there exists a condition of disease within the body, and we conclude that the seat of disturbance leading to disease is within the living cell."[3] Here it is probable that the knowledge of the college student or ordinary layman is limited. But the research chemist must turn to the problem of curing and preventing disease by the study of means by which normal processes may be maintained or restored after any disturbance. He must make an exhaustive study of the important components of the cell contents, tissue, and fluids of the body, together with an exhaustive study of foods we must have to sustain health. He must furnish a complete statement of the specific needs of the body and find out how they may be satisfied.

In this field chemists have won important victories over the deficiency diseases of scurvy and beri-beri. The source of these diseases was found to be in the lack of certain minute but vitally important principles called vitamins, found in some but not all foods. The chemical analysis of foods showing which contained vitamins paved the way for the cure and prevention of further occurrence of these diseases. Likewise, in the thyroid gland a minute quantity of the chemical element iodine is found. Its absence in the diet is likely to cause thyroid trouble such as goiter.[4] Chemists have been testing a cure for goiter by supplying iodine to the body in the form of "kelp" with food and drinking water. "Kelp" has been found to be especially rich in iodine; it is a product of the sea.[5] The importance of maintaining the proper functional activity of a gland as vital to our physical well being as is the thyroid cannot be overestimated. Still another triumph of chemistry is the gradual growth of our knowledge of diabetes, a disease manifested by a derangement of the body to take care of carbohydrates and sugars. Only a few years ago, Doctor F. G. Banting conceived the idea of preparing the insulin treatment to help diabetics to properly dispose of the sugars within the body. Although

[2] Louis Kahlenberg, "Chemistry and Daily Life," pp. 4–5.

[3] American Scientists, *op. cit.*, p. 54.

[4] American Scientists, *op. cit.*, p. 42.

[5] "Goiter, a Dietary Problem," *Scientific American*, April, 1926, pp. 248–9; "Prevention and Incidence of Goiter," *Scientific Monthly*, June, 1920, p. 39.

this is only an artificial aid, chemists have devised suitable diets which will maintain the life of the diabetic.[6] The presence or absence of health is largely determined by the proper food to satisfy the need of the body cells and owing to our knowledge of food value and cell constituents contributed by chemists in coöperation with dietists and physiologists, the present generation has been better fed than any before.[7]

The domain of drug therapy is probably the first in which chemists concentrated their time and energy. In this, cocaine is one of their first real achievements. As a local anesthetic it enables surgeons to operate on patients who are fully conscious and is an invaluable aid in locally suppressing pain.[8] Improvement of other drugs has similarly been obtained. Only recently an immense field has been opened by fighting disease germs with aniline dyes. "For years physicians have been looking for better antiseptics, despite the fact that several substances have long been successfully used. However, there have been certain drawbacks. Bichloride of mercury, for example, kills bacteria on the surface but does not penetrate. Iodine, another valuable antiseptic, is irritating and kills bacteria and tissue cells as well. The main advantage which aniline dyes, such as mercurochrome and gentian violet, have over common antiseptics is their non-irritating properties." However, here much experimentation is still necessary. One of the greatest factors in the lack of successful intravenous use of dyes is that they are "selective" in the microbes they kill. Whether or not the adaptation of a particular dye to a particular microörganism present is going to become one of the principles upon which the use of dyes for antiseptic purposes is based remains to be determined by the chemical research laboratory.[9]

For centuries the disease of leprosy has struck terror into the heart of man. There is no disease that is so repulsive and that has the physical basis for so much anguish and dismay. It is horrible to live with and difficult to die from. But even for this dreaded (and for many centuries incurable) disease chemistry has found a probable specific remedy. Dr. Roger Adams in his laboratory at the University of Illinois has isolated the clean, pure acids of chaulmoogra oil combined with ethyl alcohol and formed a new drug, with which it is possible to cure those lepers who have had the disease only a few years.[10] In this one instance, chemistry has brought a ray of hope into the hearts of thousands of lepers.

Perhaps a better conception of chemotherapy is obtained from a new drug that has also been the result of modern chemical research—adrenalin.

[6] Morris Fishbein, "Progress of Medical Science," *Sci. Am.*, Nov., **1925**, pp. 310–1.

[7] R. Binder, "Man Is What He Eats," *Sci. Am.*, Dec., **1920**, p. 370.

[8] American Scientists, *op. cit.*, p. 27, H. Hale, "American Chemistry," p. 40.

[9] "Fight Disease with Aniline Dyes," *Scientific American*, Nov., **1925**, pp. 302–3.

[10] Victor G. Heiser, "Leper Colony," *Sci. Am.*, Oct., **1925**, pp. 236–7. Associated Press Dispatch, Urbana, Ill., Jan. 26, 1927.

A chemical product isolated from the adrenalin glands of animals. Later successfully synthesized in the chemical laboratory, adrenalin causes numerous biological reactions. The outstanding reaction is marked constriction and narrowing of the blood vessels; applied to a cut surface it causes the blood vessels to shut so completely that hemorrhage ceases. A valuable instrument in surgery in controlling hemorrhage in parts of the body where other means are ineffectual. So spectacular are some of the results obtained with adrenalin that newspaper accounts are constantly appearing of corpses miraculously restored to life by its use.[11] It is not a drug with mysterious curative powers, but a chemical agent with definite biological effects which may be used to counterbalance known biological abnormalities in disease.

There are other vital secretions of the internal glands, of which the isolation of the pure principles has been undertaken to some extent by chemists, but which must be given still further attention;[12] for example, the pituitary and so-called sex glands. Drugs have been found with which the action of many of the vital organs may be varied at will. Strychnine increasing peristaltic movements in the intestines; morphine decreasing them—atrophine hastening heart action; digitalis slowing it. Iodides increasing bronchial secretion; benzoic acid decreasing it. Caffeine increasing urinary output.[13] Everyone of them a chemical agent producing definite biological reactions to maintain the healthy functional activity of the body cells.

Direct curative agents for infectious diseases have been found in the form of antitoxins, bacterial vaccines and serums. Development of rudimentary chemical defenses is the main way in which the body automatically overcomes infectious diseases within a few days after receiving infection. Quinine, a toxic substance which kills all forms of animal life, can be tolerated by the human body in sufficient doses to kill invading germs of malaria. Salvarsan can be tolerated in doses sufficient to free the body from syphilis. Antitoxic serum may be administered in sufficient amounts to neutralize poisonous products absorbed from a diphtheritic throat.[14] These sera have effected a saving of life not possible any other way. In diphtheria, for example, the usual death rate of 49 per cent has been brought down to less than 2 per cent.[14]

Great as have been the achievements of chemistry hitherto, its power to contribute effectually toward the eradication of disease and conservation of good health has by no means been exhausted. Rather, the achievements of the past are but an indication, we may confidently believe, of

[11] "Physical Basis of Disease," *Scientific Monthly*, April, 1925, p. 420.
[12] American Scientists, *op. cit.*, p. 36.
[13] "Physical Basis of Disease," *op. cit.*, April, 1925, p. 420.
[14] *Ibid.*, January–June, 1926.

what will be accomplished in the future.[15] Tuberculosis, pneumonia, and cancer form a triumvirate which has as yet only partially succumbed to chemical research.[16] Thousands of attempts have been made to secure a curative serum for tuberculosis but with no success. The essential chemical defenses against the tuberculosis germ apparently do not exist in usable quantities in the blood. The essential defense is presumably located in some other part of the body,[17] just where is unknown. Cancer, the horror of middle age, and pneumonia, the scourge of the robust and healthy are typical of the numerous problems confronting the research worker and waiting solution. Somewhere, sometime, nature will give up its secret to the most patient, faithful, and courageous worker. Never a year, hardly a month passes by but that still more is added to our present store of knowledge. Eventually, even the ultimate questions of life, the problem of heredity from generation to generation, the chemical structure of brain tissue—underlying processes of thought, memory, and feeling—will be answered by the chemical investigator.[18] The future is rich with promise. There is only a need for workers and suitable means and conditions under which to work. The average university research worker hasn't the equipment, leisure, or funds for such work as is required. He must content himself with some minor, often unimportant, phase of the problem. The importance of such work must be brought home to the general public. Then, and then only, will the adequate support be provided and until then it is for the valiant few to emblazon high their ideals! Ideals of freedom from disease, health of body, health of mind, and happiness for untold millions.

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[15] Alexander Findlay, "Chemistry in Service of Man," p. 242.

[16] American Scientists, *op. cit.*, p. 34; *Ibid.*, p. 16.

[17] "Physical Basis of Disease," *Sci. Monthly*, **20**, pp. 178–80 (Jan.–June, 1923); Feb., 1925.

[18] American Scientists, *op. cit.*, p. 26.

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12. Victor G. Heiser, "Leper Colony," *Scientific American*, Oct., **1925.**
13. "Physical Basis of Disease," *Scientific Monthly*, Jan.–June, **1925.**
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Cites Agriculture's Gains through Work of Scientists. The benefits derived by agriculture from the applications of science were outlined by Secretary of Agriculture W. M. Jardine in a recent address before the American Institute of Chemists.

In conclusion, Dr. Jardine made a plea for greater attention to, and increased support for fundamental research in pure science. He said in part:

"American science, I am convinced, needs to concern itself more with fundamental research than it has done heretofore. No country in the world has made such progress in applied science, but our record in pure science is not so flattering. Since 1900, when the Nobel prizes in physics, chemistry, and medicine were inaugurated, 76 awards have been made. Of these, 24 went to Germany, 11 to England, 10 to France, 6 to the Netherlands, 5 to Sweden, 4 to the United States, 3 to Denmark, 3 to Switzerland, 2 each to Austria, Canada, Italy, and Russia, and 1 each to Belgium and Spain. On the basis of population, the Netherlands, Denmark, Sweden, and Switzerland received one to every million inhabitants; Germany one to every two and one-half million; Austria one to every three million; England one to every three and one-quarter million; France one to every four million; the United States, one to every twenty-nine million. This is the situation despite the fact that we have vastly more students in colleges and universities in proportion to the population than has any other country in the world. The difficulty seems to me two-fold: we are not laying enough emphasis on pure science in proportion to our emphasis on the applications of science; and we are not stimulating and training an adequate personnel in scientific research."—*Science Service*

Insulin Action Duplicated by Synthetic German Drug. A synthetic drug that acts like insulin in remedying diabetic conditions, but which can be taken by mouth instead of necessitating troublesome daily injections with a hypodermic needle, is the discovery reported by Dr. E. Frank of the University of Breslau.

The new compound is a derivative of guanidine, a substance long well known to organic chemists, and has been named "synthalin" by its discoverer. It is not nearly so powerful as insulin in the crystalline form, first prepared by Dr. John J. Abel of the Johns Hopkins University, but its effects are indistinguishable from those of the natural drug produced from the pancreatic gland. Injected into the blood stream of laboratory animals afflicted with diabetes, it quickly reduces their blood sugar concentration to normal, and an overdose produces the convulsions that are a symptom of excessive insulin. These convulsions can be cured by injecting sugar solution, as they are in the case of those produced by the natural insulin.

Dr. Frank states that the new chemical will be of use chiefly in the treatment of mild and moderately severe cases of diabetes, and he cautions prospective users to be exceedingly careful in regulating the size of the dose. Synthalin alone, he says, will not avail against diabetes in its more advanced stages. In these the frequent injection of insulin is still the only effective treatment. But even here, he claims, synthalin will be useful as an auxiliary medicament, for by swallowing properly adjusted doses of it the patient can cut the number of insulin injections needed daily from three down to one.—*Science Service*

THE RELATION OF CHEMISTRY TO THE ENRICHMENT OF LIFE*

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Life of today has become very complex. We use daily, numerous articles which had never been dreamed of by our forefathers. Indeed, this century is characterized by the steady stream of improvements that are entering into the daily lives of mankind. These additions to our comforts are all contributions of the various branches of modern science. It is probable, however, that chemistry has contributed more than any other single science. Indeed, so universally do we use and enjoy the products of the chemist and so accustomed have our minds become to his many marvels that we take them for granted. Chemical ingenuity, almost every day, produces something new for us to wear, eat, see, or work with. A few exclamations greet each new product and then most of us hurry along to the next marvel of this science. These gifts of the chemist are directly related to us. They clothe and feed us better; protect our health; diminish our labors; lower the expenses of life; and do everything to make our lives more enjoyable. This is true enrichment of life.

The most vital relation between ourselves and chemistry is found in its connection with our foods. Regardless of the kind of food, chemistry has important associations with it before it is ready for our use. The very growth of the plant or animal is a complex chemical change. Our bread, our butter, our meats, our sugar, and the rest of our foods would have interesting chemical stories to relate if they could only speak. Sugar, for instance, passes through six major processes before it becomes the white, crystalline product that we know.

Then, too, we must remember that cooking, a most vital operation to us, is almost entirely a chemical process. This is one reason why chemistry is taught in all domestic science courses. Since cooking is a chemical process the chemist can be expected to develop improvements and substitutes. Look into the kitchen of any modern, up-to-date house and there you will see the mute testimony of what he has done. There can be found the vegetable cooking oils made from cottonseed or corn, such as "Wesson" or "Mazola" oils; the sirups made from corn starch, such as "Karo;" the coffee substitutes made from wheat, such as "Postum;" the pure vegetable shortening made from cottonseed oil and hydrogen, such as "Crisco;" and countless small articles such as extracts, coloring materials, flavors, and baking powders.

The preservation of food is a branch of the culinary art that is closely allied with the science of chemistry. Foods that have been preserved

* Prize-winning college essay, A. C. S. Prize Essay Contest, 1926–1927.

by salting, smoking, canning, and use of chemical preservatives are common items in every household. A recent example of a new idea in this field is to be seen in the so-called "carbonated ice-cream." This developed from the fact that products such as butter and ice-cream keep better when churned with carbon dioxide. Indirectly the chemist conserves the foods that are cooled in our ice boxes by refrigerating machines such as "Frigidaire," for these machines utilize chemicals such as ammonia, sulfur or carbon dioxide, or methyl chloride as refrigerants.

But even after all these valuable gifts to mankind, the chemist does still more. His research in foods has developed new theories that are of invaluable aid in preparing proper diets. One of his discoveries in this field that is known to nearly everyone is the importance of vitamins. By application of this knowledge the world is ridding itself of the deficiency diseases, beri-beri, rickets, and scurvy. Consequently, this knowledge has been of great service in cherishing the most valuable possession of life—good health. This may eventually prolong our lives beyond the allotted three score and ten years. Is not this true enrichment of life?

In further relation to our health, which is synonymous to our happiness, the chemist has done wonders. Nowhere in all its many fields of application has the chemist done more good and enriched our lives to a greater extent than in the realms of medicine and surgery. He has made chemistry the chief weapon of man in his lifelong struggle against the germs that invade his body. His discoveries have brought relief to the sleepless and suffering and deprived surgery of its anguish. Let us now consider some of the everyday applications.

In every home, business building, factory, and shop one can almost invariably find a medicine chest or first-aid kit which contains remedies for minor ailments, sterilized bandages, antidotes for poisons, and hundreds of other substances. Everyone is familiar with simple remedies such as "Epsom salts," "milk of magnesia," "iodine," "peroxide," "mentholatum," "vaseline," and "aspirin." New germicides continue to come from the chemist's laboratory, two recent additions being mercurochrome and hexylrescinol.

In addition to the myriad of simpler medicants, numerous synthetic substances have come from the almost magical laboratory of the chemist which contributes greatly toward allaying the suffering of humanity. No money value could be placed on the service to mankind which the discovery and use of anesthetics, such as chloroform and ether, have made possible. Chemistry has even improved upon nature by preparing procaine and synthetic morphine, which have the valuable medical properties of the natural drugs but lack their toxic qualities. Another substance that has been of great value is adrenalin. With its isolation and appli-

cation modern "bloodless" surgery became an established process. The most recent medical marvel that has been made possible by chemical knowledge is the extraction of insulin. This material is used as a serum for diabetes and offers relief for a formerly unassailable ailment of mankind.

Caring for the public health has been one of the greatest problems men have had to cope with since they have begun to live together. The most dangerous source of disease is a contaminated water supply. Thus the purification of public water supplies might be classed as one of the greatest services the chemist has rendered to our communities. With his processes widely established, epidemics such as typhoid fever are becoming a rarity.

Another essential factor of our lives which the chemist has improved and added to is our clothing. He developed the finer details in the manufacture of cloth from the raw cotton, flax, silk, and wool. Without his aid to the textile industries, our clothing would not be nearly so satisfactory or reasonable. Besides improving the manufacturing process for the older fabrics, he has placed in the hands of the manufacturer an entirely new fabric which is made by several chemical processes from cellulose-bearing substances on the order of cotton wastes and wood pulp. This material which is commercially known as "Rayon" has all the luster and gloss of silk and the advantage of lower market value. As a natural result it has found enormous use in the last few years. These artificial fabrics are still being improved on and a cloth made from cellulose acetate fibers is now being manufactured. This cloth is naturally water-repellant; it holds dyes well, it is stronger than natural silk and resembles it more closely than any other substitute for silk. Thus it promises to become very useful.

The chemist has also been the one to provide the numerous brilliant colors which "Lady Fashion" prescribes at present. To supply the dye demand from dye-giving plants would necessitate large tracts of land and much labor. The synthetic dyes that the chemist makes from coal tar are vastly superior to the natural product in respect to purity, brilliance, fastness, and cheapness. Thus this land and labor can be given over to a much better purpose, that of producing food.

Besides lacking the many improvements that have been spoken of, our forefathers were also forced to struggle along almost entirely with candles for light and wood for fuel. Today candles have few uses other than for ornaments or religious services although they are much better than the older ones. Instead, our light is obtained from a tungsten filament, glass enclosed, and nitrogen filled electric lamp. In rural districts the source of light is a kerosene lamp or, better yet, a gasoline lamp utilizing a Welsbach gas mantle. This mantle is composed of a delicate framework of

cerium and thorium oxides. Wood is rarely used for fuel, as good wood has too many other valuable uses. Therefore, we use coal, crude oil, and natural and artificial gas instead and, thanks to the chemist, quite efficiently.

It must have been difficult for our ancestors to start their fires with their crude flint and steel. The development and introduction of matches effected a considerable change in this condition and starting a fire today takes only an instant. Matches are so common that we often underrate their importance. They might truthfully be termed "the biggest little thing" that the chemist has bestowed upon man.

Objects made of metal play an important part in our daily lives and are closely associated with nearly every field of human endeavor. In fact, this extensive use of metals is the outstanding characteristic of our present civilization. Real civilization did not begin until man had learned enough chemistry from experience to obtain metals, such as iron and bronze, for his use. Then progress became rapid and today nearly all available metals have been pressed into service. Metals practically unheard of a hundred years ago are now in daily use. Our great-grandfathers possibly never heard of such metals as aluminum, chromium, tungsten, molybdenum, and vanadium. Yet today they have extensive applications that lighten our labors and multiply our joys.

Next to the metals, glass is probably our most useful inorganic chemical material. Tableware, bottles, mirrors, and windowpanes are a few prominent examples of the various applications of glass. For beauty in glassware the delicate etchings made by hydrofluoric acid or the iridescense of cut glass can hardly be rivalled. The chemist is always trying to better his past products and develop new ones. "Pyrex" glass is one of his recent improvements. This product makes very fine, durable glassware as it is tougher and less affected by heat changes than ordinary glass. The latest development in this line is seen in the so-called flexible glass. This substance is not exactly a glass as it is not siliceous but organic in composition. This material should become extensively used as it overcomes one of the greatest disadvantages of siliceous glass.

Of all the forms of modern machinery, the automobile has done more to directly enrich our lives than any other single machine. Everywhere we go they are sure to be found—in the large metropolis or in the remote rural districts. The automobile has become a most satisfactory servant for man. The successful development of the automobile as we know it today was as much a triumph for the chemist as it was for the engineer. There is hardly a part in a car whose origin cannot be traced to chemistry. The fuel, the lubricant, the metals of the engine and body, the rubber tires, the glass windshields, and windows—all would be impossible to obtain were it not for the chemist. Without these things there could

exist no automobile. Besides making the automobile possible the chemist has done much to place it within reach of nearly everyone. The modest prices of automobiles are due almost entirely to a chemical product called "high speed steel." One of his latest developments along this line is the pyroxylin lacquers, such as "Duco" and "Opex." These paints have effected a considerable saving in price and time necessary to paint an automobile. Another of his aids to the automobile is the "anti-knock" mixtures that increase the efficiency of the gasoline. There is still much that the chemist can do in the field of automobile production. In all probability he will make the automobile a still greater furtherance in our lives.

In concluding, the reader must realize that this paper has only grazed a few of the many pinnacles of chemistry as related to the enrichment of life. Only the more outstanding examples have been chosen. Many of the minor contributions of the chemist, such as rubber, paper, inks, celluloid, and Bakelite, have been neglected as they would necessitate more detail than the scope of this paper can allow. Yet even from these few examples it is evident that chemistry had done wonders for mankind in the past. Its applications to our necessities and comforts have almost been without number. It has wrought great advancement in our conditions of life and modes of living. But great as the past achievements of the chemist have been, those that he will develop in the future will, assuredly, be still greater. This is to be expected, for chemistry is as yet only emerging from its infancy. The chemist has before him a host of problems such as the synthetic manufacture of many of our natural products the profitable transmutation of the elements; the tapping of the vast store of atomic energy; and the conquest of the present impregnable diseases of mankind, especially cancer. All of these will wield a vast influence on our lives, once they are solved. Thus it might be said that the chemist holds the key to the future—may he use it to the best advantage of all mankind!

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USE OF POTASSIUM FERROCYANIDE AS A CONFIRMATORY TEST FOR ZINC

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As the usual confirmatory test for zinc—the green incrustation formed by fusion with cobaltous nitrate—has never given my students very satisfactory results, I tried out the ferrocyanide test in my qualitative classes last fall. The test was adapted from the procedure used in the volumetric determination of zinc by the ferrocyanide method and is as follows:

Dissolve the supposed zinc sulfide precipitate in 5 cc. 6 *N* HCl. Boil to remove H_2S. Just neutralize with ammonium hydroxide and add 3 cc. concentrated HCl. Heat nearly to boiling and add 5 cc. 1 *N* $K_4Fe(CN)_6$ solution. White precipitate of zinc ferrocyanide, becoming flocculent on addition of excess reagent, shows presence of zinc.

Tabulated student results are given in the following table.

Year	Times Zn reported correctly	Times Zn missed	% Correct
1926 (new test)	52	6	89.6
1925 (old test)	41	6	88.1
1924 (old test)	19	6	76.0
1923 (old test)	14	3	82.4
Total (old test)	74	15	83.1

The ferrocyanide test thus shows a marked improvement in results over the former test and warrants further use.

We cannot command veracity at will; the power of seeing and reporting truly is a form of health that has to be delicately guarded. The penalty of untruth is untruth.—GEORGE ELIOT

THE RELATION OF CHEMISTRY TO AGRICULTURE*

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To the agricultural chemist are entrusted some of the keys of civilization. He may be the arbiter of destinies, the molder of the fates of nations.

The researches of Pupin, Hedin, Henderson, Crile, Morgan, Jacques, Loeb, and a score of other biologists, physicists, chemists, and bio- and physico-chemists have established rather certainly the hypothesis that the functionings of living organisms are the results of chemical reactions, reaching enormous complexity, within those organisms. There is now little doubt that in its physical aspect life is essentially of chemical constitution of tremendous complexity, particularly in its advanced forms, yet always a problem of chemistry, to be investigated, where its intricacy does not completely confound the human mind by the principles of that fundamental science of matter.

This hypothesis, which may at present be taken as a tentative fact, suggests at once the known principle that the continued health of any living thing, of whatever degree of complexity its organization, requires the presence within it of those elements which were brought together in the misty past to form the first primitive cell, together with those which that particular organism has added to itself in the course of its racial life.

From these considerations, it follows at once that of all the natural sciences chemistry is best prepared to deal with the question of the production and supervision of the food supply of the human race, for this problem is essentially one of supplying to the human organism in the most efficient manner possible such elements as, determining as they do its physical and mental happiness, are lacking to it at the moment.

The labors of the chemist in this enormous and important field may be divided into two groups—those which deal with the efficient production of correct food and those which deal with the supervision, or "policing," of the finished product. Space forbids a discussion of the second phase of the work, but the first may be briefly considered.

The work of chemical food production embraces two vast and widely differing fields, which may be termed for convenience "artificial" and "natural" food preparation, although as descriptive terms the titles are not strictly accurate. In the former field, organic reactions are so carried out that food may actually be synthesized, in the latter, animals and plants, the "food factories" of Nature, are so supplied with raw mate-

* Prize-winning college essay, A. C. S. Prize Essay Contest, 1926–1927. Mr. Haskins appends an account of some "original experiments relative to the chemical nutrition of plants," together with illustrative photographs. This material is not reproduced here.

rials that their operation may be the most efficient and their yield the highest possible.

The first division of the work is one looking to the future for its development. Jorgensen and Kidd in 1916 and Baly in 1924 have shown that sugars may be manufactured in the laboratory, under the light rays of highest chemical activity, and other significant researches have been made. What Time may hold for this branch of chemistry in the service of food production, when its comprehension of organic reactions shall have been extended, can hardly be predicted.

The "natural" production of suitable aliment by chemical means is the medium through which the food chemist serves the world at large. Two fields are included by it, that of chemistry in meat production, and of chemistry in agriculture.

Space forbids a discussion of the evidence which tends to show that the living plant is the source upon which the entire realm of higher organisms depends for its food supply, but the hypothesis has so long and so universally been accepted that it may properly be asserted as a truth without demonstration. Reasoning upon this statement, it may be seen that the chemist, in controlling the production of the crops of the world, controls at once its supply of meat and vegetable nutriment. The service of agriculture, therefore, is of the two divisions the more fundamental in the work of chemistry in natural food production. To this field we may now turn.

Logically, there should be three divisions of the chemist's work with plants—proper feeding, to permit of maximum increase in bulk of useful material as maturity approaches, protection from insect and fungus parasites, to permit the plant to develop unmolested and to maintain itself properly at maturity, and selective breeding, to fix in the race itself the characteristics which, amid the proper conditions, will determine a maximum yield. In the last-named division, however, is encountered a problem with which chemistry is at present unprepared to cope. Only biology, which must handle the matter without attempting to understand it, equipped as that science is with a vast amount of experimental evidence in the field, can at present deal with that stupendously complex compound, the chromatin of the cell. In consequence, the great services which chemistry renders to agriculture are largely confined to the first two fields. The first alone may be taken up.

The leaf of the metazoic plant is the organ of primary importance in its food manufacture. Within the palisade cells, and those of the mesophyll, lie the chloroplasts, containing the four pigments which are associated with photosynthesis—chlorophylls A and B, carotin, and xanthophyl.

In the process of photosynthesis, the following reaction takes place:

$$\underset{\text{Soil water}}{6H_2O} + \underset{\text{Carbon dioxide of air}}{6CO_2} \longrightarrow \underset{\text{Simple sugar}}{C_6H_{12}O_6} + 6O_2,$$

Of all external reactions in Nature, this is probably the most necessary to man, and it is toward its furtherance that the labors of the agricultural chemist are directed.

In general, the rapidity of growth and the condition of a crop are determined by five factors—the humidity and temperature of its surroundings, the relative composition of the air which bathes it, the amount and quality of the light which it receives, and the fertility of the soil into which it has struck its roots. Although three of these factors are purely physical ones, they must nevertheless receive the careful attention of the chemist, for they have great bearing upon the process of photosynthesis. Thus, when the relative humidity of the atmosphere falls too low, the guard cells of the stomata of the leaf immediately close it to the outside world. Intra-molecular respiration at once begins, attended by decomposition of such sugar as is present in the leaf, while sugar manufacture itself is halted. A fall of temperature below the optimum immediately decreases the rate of photosynthesis, while in the absence of radiant solar energy carbon assimilation will not take place at all. Therefore, the chemist must adjust these three physical determinants to approach the optimum as nearly as is possible before supplying the crop with the chemical determinants of plant growth.

The third and fifth conditions of the list above concern directly the chemical nutrition of plants, to which we may now turn.

There are invariably present in living plants the elements: oxygen, silicon, phosphorous, potassium, calcium, carbon, hydrogen, nitrogen, sulfur, magnesium, and iron. Of the first three of this list there can be no possible lack. As water, hydrogen and oxygen are omnipresent while oxygen for purposes of respiration is readily to be obtained from the atmosphere.

Silicon makes up 27.74 per cent of the earth's lithosphere, while by simple arithmetical calculation from assembled data, it has been found to constitute from less than 0.10 per cent to about 0.50 per cent of the total bulk of the plant.

Magnesium, iron, and sulfur are also present in sufficient amounts in most soils for crop requirements. All three are of first importance to vegetation. Magnesium, as has been shown, is a constituent of chlorophyll, while iron is associated in the formation of those pigments. Sulfur, although indispensable, particularly to legumes, is of uncertain function in the plant. Among the legumes, it may possibly serve in the development of the microörganisms of the root nodules.

With the single true exception of the element carbon, and the partial exception of nitrogen, all of the five remaining "critical" elements must be present as compounds in the soil in order to be obtainable to the plants.

All soil compounds may be classified under three heads—those soluble

in water and dilute acids, those soluble in acids of greater concentration, and those which are practically insoluble, and are decomposed only by the strongest acids. Since all the reactions of the living organism must take place in colloidal solution, or at least in a state of dispersion so closely resembling the colloidal as to be practically identical with it, the plant is rendered utterly unable to utilize any of the last class of compounds, which might otherwise serve as valuable foods. By reason of this fact, and the circumstance that soluble soil compounds have a tendency, if not immediately used, to leach away, or to become "fixed" as insoluble, and therefore useless, ones, the crops of the world stand in almost constant need of available soil compounds for their best growth and development. It falls very naturally to the lot of the chemist to regulate the quantity and quality of this all-important food supply.

First in importance stands the element nitrogen. Nitrogen is a constituent of all proteins and is, therefore, essential in the building of protoplasm. When it is withheld, immediate and visible effects appear in the plant. The leaves lighten in color, yellowing as they do so, and are at the same time much reduced in size. The entire organism speaks visibly of its acute starvation.

The metazoic plant, affording an excellent illustration of the principle everywhere manifest that the advances in complexity of all higher organisms have been heavily compensated, has entirely lost the power, so well developed by certain unicellular forms, of "fixing" atmospheric nitrogen. Plants of the odd group *Leguminosae*, to be sure, represent a sort of exception to this statement, although their actual power of fixation is no greater than that of other plants. They have entered into a remarkable symbiosis with certain soil bacteria, whereby the metazoic organisms are supplied with nitrogen fixed from the air by the bacteria, which receive protection, and perhaps also carbohydrate food, from their hosts. For this reason, high nitrogen concentration in the air may be of great benefit to legumes, but on the whole, atmospheric nitrogen is of little importance in agriculture.

The most satisfactory methods by which nitrogen may be prepared for the crops are those obtaining in the various fixation processes. These are very numerous, and are every year becoming more so, but only a few of those commercially the most successful will be considered here.

The Pauling furnace, in operation today in Austria, Italy, and France, is a good representative of the arc process for the fixation of atmospheric nitrogen, to which type also belong the Birkeland-Eyde and the Schönner processes. All three are possible only where electric current is readily available and cheap. In each case the end product is nitric oxide, which can be fairly readily converted to a soluble nitrate.

We now come to the processes in which the end product is ammonia,

the Haber and the cyanimid. The Haber process will serve as a roughly typical example.

Nitrogen and hydrogen, when subjected to certain conditions of temperature and pressure, will unite to some degree to form the gas ammonia. This fact had long been known, but the reaction is a reversible one, and until the equilibrium had been carefully studied by Haber and Van Oordt, there seemed little possibility that it would ever become a practicable matter to carry out the operation upon a commercial scale.

Haber and Le Rossignol, with the coöperation of the Badische Anilin und Soda-Fabrik, succeeded in working out a process which presented a relatively satisfactory solution to a problem long considered insoluble. Using the most favorable concentrations of nitrogen and hydrogen (1:3), the greatest possible ammonia concentration is obtained by the use of very low temperatures and high pressures, in direct accord, of course, with Le Chatelier's principle, since the reaction in the direction of ammonia is exothermic. The following table will illustrate this:

Temperature Centigrade	Pressure 1 Atmosphere	100 atmospheres	200 Atmospheres
500	.013	10.7	18.1
550	....	7	12.2
600	.048	4.5	8.3
650	....	3	5.8
700	.021	2.1	4.1

(NH_3 concentration)

However, as suggested in the table, in order to secure reasonable catalytic action temperatures as high as 500 degrees must be used. Haber and Le Rossignol, therefore, used pressures up to 2000 atmospheres, beyond which it was difficult to go, and temperatures between 500 and 700 degrees Centigrade, which, with the aid of carefully constructed catalysts, have given remarkable ammonia yields.

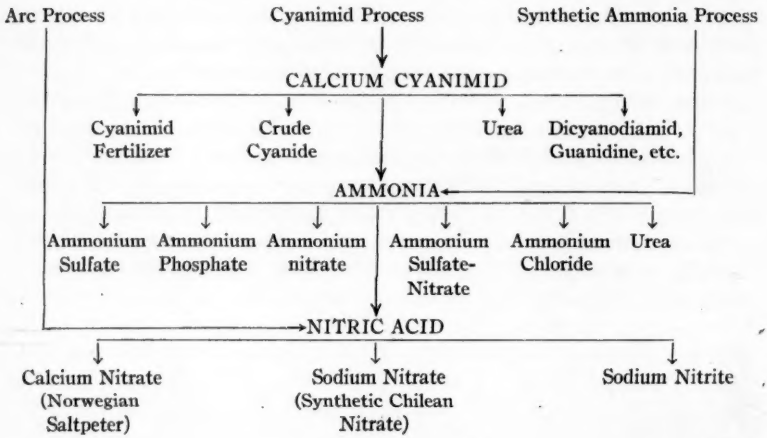
The ammonia thus obtained may be converted to a soluble nitrate in various ways, of which space forbids a discussion. The nitrifying bacteria are sometimes allowed to perform this work.

In closing, the chart which appears on the following page gives a very excellent summary of the interrelation of the various nitrogen fixation processes and their products.

Potassium is the great donor of resistance to the plant and apparently assists in carbohydrate manufacture. When the crop is deprived of this all-important element, it exhibits no marked outward change of condition, but is apt to fall an easy prey to disease. Since potassium is an element looking naturally to the soil as the resting place of its compounds, which are solids and always soluble, it may be taken from Nature and used as a fertilizer with no intermediate process. Usually the chloride is taken,

although sometimes the sulfate is also used. Both of these compounds are obtained very largely from the world-famous beds of Stassfurt.

Calcium, although an essential constituent of plant soils, is of uncertain function in crop growth. It appears to assist in giving rigidity to stems



and leaves. Its preparation as a fertilizer is bound up very frequently with that of phosphorous, under which it may be surveyed.

Phosphorous is a very essential constituent of plant nutrition. It is intimately connected with the functions of cell nuclei, and appears to influence cell multiplication and growth. The following table will illustrate the great use made of it by plants:

Crop	Number of pounds of phosphorus removed per acre
Sugar Cane	6
Sugar Beet	6
Tobacco	7
Corn	9
Wheat	6
Oats	6
Barley	7
Clover Hay	8
Average	6.875

Deposits of calcium phosphate occur in Florida and Tennessee, as well as in several western states. The normal salt is insoluble, but is converted to the soluble super-phosphate according to the following reaction: $Ca_3(PO_4)_2 + 2H_2SO_4 \longrightarrow Ca(H_2PO_4)_2 + 2CaSO_4$. In practice, the calcium sulfate is hydrated: $2CaSO_4 + 4H_2O \longrightarrow 2CaSO_4.2H_2O$. The mixed salts are incorporated together into the fertilizer.

Ranking among the elements of highest importance to the crop stands carbon. Upon carbon, available to vegetation as carbon dioxide, the plant is dependent for its sugar manufacture.

The normal concentration of carbon dioxide in the atmosphere varies, according to Lundegardh, from 0.0256 to 0.0329 volume per cent. If this concentration is increased, gratifying results almost invariably follow, the plants reaching maturity in an amazingly short time. About 1918, Riedel, in Essen, obtained flue gases from a steel factory, purified them, and piped them into an adjoining field of beets, with surprising increase of yield. Perhaps more than any other phase of argicultural chemistry does the principle demonstrated by Riedel demand development, for by its successful application the crop yield of the world may be greatly augmented, and at once the smoke nuisance of our cities—an ever-increasing menace—be diminished.

Fast-Growing Trees Bred for Paper and Rayon Uses. Fast-growing hybrid poplar trees grown as a farm crop may before long compete with corn and cotton for a place in the farmer's fields. Dr. A. B. Stout of the New York Botanical Garden, Dr. Ralph H. McKee of Columbia University, and E. J. Schreiner of the Oxford Paper Company, announce that they have succeeded in obtaining new hybrid varieties of poplar that will reach a trunk diameter of eighteen inches in eighteen years, giving a total yield of 100 cords to the acre. Part of the crop can be harvested at the end of ten years, to thin out the stand, and the balance when the trees have matured.

The unusually rapid growth of the new varieties, the investigators explain, is due to a phenomenon, long known to breeders, called "hybrid vigor." It is not at all well understood, but in plant and animal husbandry it is much used to obtain thriftier crops and stronger and larger livestock than can be got by sticking to unmixed species. The superior strength and endurance of the mule, a hybrid between the horse and the donkey, are credited to this hybrid vigor, and many of our best field and garden crops have been obtained in the same way. A few tentative experiments have been made in the past with hybrid forest trees, but the present work is the first endeavor to apply the principle to the development of a tree needed for a group of major industrial operations.—*Science Service*

Measures Ten-Millionth of Degree of Temperature. Using an electrical heat-measuring device so incredibly delicate that it is sensitive to two trillionths of an ampere of current and will measure temperature changes of as little as one ten-millionth of a degree Centigrade, Dr. A. V. Hill of the Cornell University has measured the temperature changes in nerve fibers during their activity. In describing his experiments before the National Academy of Sciences, he stated that his object had been to learn more about the nature of nervous action. Older theories have held that nervous impulses were not like other physiological processes, but were physical waves like light or radio waves. These ideas were based on the absence of any detectible heat given off by nerves as a result of stimulation. But with the extremely sensitive instrument devised by Dr. Hill it is possible to measure the almost vanishingly minute temperature rise that occurs in a single nerve fiber when it is caused to react. The moment of activity of a nerve is followed by a prolonged period of recovery, during which nine times the initial amount of heat is given off.—*Science Service*

THE RELATION OF CHEMISTRY TO THE HOME*

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Today, the science that is most closely connected with the essentials of a pleasant, healthful, and comfortable home is chemistry. Chemistry is a science that treats of the compositions and properties of substances and of the transformations which they undergo. As time goes by, it is becoming more and more realized that the benefits and essentials, which have not been brought into realization of the world, lie hidden in the field to which chemistry has the key.

For the purpose of seeing for ourselves the relation of chemistry to the home, let us first see how chemistry has helped to furnish man with food.

The essential thing that man has to have in order that he may exist is food. As it has been stated, "Half of the struggle of life, is the struggle for food." This has been true ever since the very creation of man by God and will always remain true as long as man exists.

Chemistry has already made, and will continue to make, many important contributions to the problems of food and its supply to the world. The problems of development and control of food industries; as well as the problems of the refinement and development of food for the home, are all problems largely for chemists to solve, and the field of work, in which chemistry has already made many worthy achievements and must continue to play a leading part.

Chemists have found by the process of analysis that all animal and vegetable foods consist chiefly of carbon, hydrogen, oxygen, and nitrogen. Certain foods contain small amounts of calcium, phosphorus, and silicon, which are used in feeding the bones and teeth; and iron, sodium, and chlorine are found in the blood. With this knowledge, chemists are already attacking the problem of producing food stuffs by combining different elemental substances in definite proportions. A great many of our food products were produced long before knowledge of their composition had ever become known. As an illustration of this, the production of sugar from the sugar beet seems to be an interesting one.

The ancient Greeks, being a curious and inquiring people, invaded India and found that there, the Indians had reeds that bore honey without bees. In the course of time, they had Europe using a kind of "edible gravel" that the Arabs called "sakkar." The Arabs invaded Spain, taking with them the instruments of higher civilization; later, the Spaniards carried their customs and produce into the Caribbean, where sugar cane thrived amazingly. England finally took possession of the Caribbean and all of its assets, and from her use of sugar cane, sugar was introduced into Germany and France. As conditions in Europe made each

* Prize-winning college essay, A. C. S. Prize Essay Contest, 1926–27.

country rely on her own products, Germany, realizing the lack of tropical resources, set to work to find new methods of obtaining sugar from some of her native products. A Berlin chemist, Marggraf, in 1747 discovered that it was possible to extract sugar from beets. At first there was very little sugar in beets (about 6 per cent) and what he obtained was dirty and bitter, but as the beet was improved upon cultivation, the percentage rose, and by improved methods of extraction the sugar finally became as pure and as palatable as the sugar from cane. This is the method by which many of our food stuffs have been produced, although many of the recent products have been formed upon the basis of composition of food.

Perhaps the most important of all the services of chemistry to food lies in the formulation of the requirements of human nutrition in explicit and practical terms, and in the determination of the relative values of different foods in nutrition, and the ways in which they supplement each other so that we may know how best to use our food supplies in order to be as well nourished as possible. For proper nutrition is an even greater factor in health, happiness, and efficiency than the world has previously supposed.

About 1912, the work of Hopkins, in England, and of Osborn, Mendel, McCollum, and Davis, in America, made it clear that an adequate food supply must furnish certain substances absolutely essential for life which are called vitamins.

Thus it has been shown that chemists have found, through experimental work, the composition of foods and the values and requirements of food for each person.

The next most important necessity of the home is clothing. We shall see how chemistry has aided man in producing clothing materials.

It is true that very few products ever reach the stage of final consumption without having undergone some chemical process. This is a matter of common knowledge, but is sometimes overlooked. Every metal has to be refined; fibers must be bleached, purified, and dyed; leather, rubber, and many similar products must be preserved. All cloth, whether it is cotton, woolen, silk, or artificial silk, must be bleached, purified, and dyed before it can be used for clothing. Leather, from which shoes, belts, pocketbooks, and the like are made, must be tanned, a process in which it is treated with infusions of vegetable tannin.

Because of the fact that the demand for articles made of leather was greater than the supply of raw material, the creative chemist devoted much study to the problem of producing artificial leather substitutes. The most common leather substitutes are made by treating woven fabrics with thick coats of pyroxylin in the proper solvents. The enamelled and patent leathers are prepared by treating natural leather with pyroxylin.

Chemists have developed methods by which many natural and artificial products have been derived from cellulose. Cellulose has been the basis of more different industries than any other material. The following materials are products which have been derived from a raw material and would never, very likely, have been manufactured had it not been for chemistry:

1. Textile fabrics made from vegetable fibers.
2. Mercerized textile fabrics made from cellulose.
3. Paper, vegetable parchment, cardboard, etc.
4. Pyroxylin solutions.
5. Pyroxylin plastics.
6. Acetate plastics.
7. Vulcanized fibers.
8. Artificial leather.
9. Photographic films.
10. Products produced from wood distillation.

Perhaps some of these articles do not furnish any aid toward making clothing, but surely they aid in furnishing the home.

The science of chemistry has done a great deal to reveal the methods of manufacturing textile fabrics. As needs have arisen for increasing the supply of textile fabrics care has been given to the cultivation of the natural raw products so that quantity and quality may be improved. But as the demands increased more rapidly than the natural supply, attention has been given to finding new methods of producing, by purely artificial means, fibers suitable for use in textile manufacture.

In no line of development has there been any more marked progress than in the manufacture of artificial silk by purely artificial means. Artificial fibers made from cellulose are called rayon. Chemists have discovered several methods for making rayon; the viscose process is most used in the United States.

After chemists have devised methods for producing materials of wool, cotton, and silk, then it is necessary that they attempt to produce methods for dyeing these materials.

The coloring of garments and ornaments has always been of great interest to man. Such things were colored by the use of vegetable and animal substances by the most primitive races. The human eye delights in color-giving substances. Formerly the common dyes were supposed to exist already in the plant and animal substances, and so came to be called natural dyestuffs. Among the most important of these are logwood, fustic, indigo, Tyrian purple, and the natural dyes from minerals. These dyes were used entirely until the nineteenth century, when chemists began to investigate these natural dyestuffs for the purpose of deter-

mining the composition of such colored substances, with a view of producing them artificially. In 1862 Unverdorben succeeded in discovering aniline and in 1856 W. H. Perkins, an English chemist, discovered the first synthetic dye; later he discovered and perfected the method of producing dyes from coal tar. These discoveries have done much toward the final completion of clothing materials. They have also aided in the coloring of fixtures and furnishings for the home.

Now that we have seen how chemistry has helped man to supply himself with food and clothing, let us take up the matter of fuel, and see if chemistry has done anything toward bettering and increasing our fuel supply.

It has been stated that human culture began when it became known that fire existed, and that it could be used to serve man's needs. Today fire has three important parts to play in the household; they are: heating the home, lighting, and cooking of food. These fuels are divided into three classes—solid, liquid, and gaseous. The solid fuels are coal, wood, charcoal, and peat. The liquid fuels are the oils and alcohols. The gaseous fuels are the natural and artificial gases which are readily combustible. These three classes of fuels are of vegetable, mineral, and animal origins.

Coal and wood are the two most common fuels. There is little to be done to coal or wood chemically if it is to be used as an ordinary fuel but if one wishes to produce a gaseous fuel from coal he must use chemical processes in order to do so. Coal gas is a product produced by the carbonization of bituminous coal in retorts especially designed for the purpose. Water gas is an artificial gas which consists of hydrogen and carbon monoxide. It is prepared by passing steam over incandescent carbon and is used for domestic heating and lighting.

Because of the fact that many rural homes have no way of securing either natural or artificial gas for lighting and cooking purposes, a device has been manufactured to generate acetylene gas for the home. This device depends upon the fact that water on reacting with calcium carbide generates acetylene.

Kerosene has been made a less common source of heat and light than formerly was the case by the introduction of the electric power plants, but it is still used to a great extent in rural communities where neither artificial nor natural gas is available. It is a petroleum product produced by a refining process. Gasoline is another product which is produced in a similar manner.

Since we have mentioned materials commonly used in lighting and heating the home, it would not do to refrain from mentioning the use of electricity. It is true that electricity is more for the physicist to deal with than for the chemist, but he must have the materials produced by the

chemist before he can develop anything out of electricity. The part that chemistry plays with electricity is the making of electric light bulbs, coils, and all sorts of apparatus. The discovery of tungsten and the development of a technic for handling it have aided the manufacture of lamp filaments. This has done much toward the production of electric light equipment because of the fact that the resistance to the current of electricity is great enough to raise the heat of the filament to the point of incandescence, where it will glow and emit light.

Next of importance to food, clothing, and fuel in life is furnishing our homes so that they are comfortable and cheerful.

Upon entering any modern home we notice many articles, which we have the great pleasure of using because of the long hours of labor spent upon these articles by some chemist. There are the bricks from which the fireplace is made. These are made of certain types of clay, molded into the desired forms and baked in a furnace or kiln. The glass in the mirror is made by fusing sand with two chemicals, one of which is sodium or potassium carbonate or sulfate, the other of which is calcium oxide, lead oxide, or the oxide of some other divalent metal. On the back of this glass is placed a solution of silver nitrate. The wood-work is stained with numerous pigments over which is placed a varnish, which very likely consists of resin or a mixture of resins dissolved in alcohol. The artificial leather on the divan and armchairs is made by treating woven fabrics with thick coats of pyroxylin in the proper solvents. The linoleum on the floor is made of oxidized linseed oil pigment, corkdust, and fillers, mounted on a canvas backing, the canvas usually being painted on the under side. The candle sticks on the mantle appear to be sterling but if closely examined will be found to be made of some metal, which has been electroplated. The keys on the piano appear to be made from ivory, but they are made from an artificial product, which consists of pyroxylin mixed with camphor and alcohol and passed through heavy rollers. The wall paper is composed of cellulose and is made from a mixture of cotton or linen pulp and wood pulp. In fact as we stop and consider the actual making and composition of the furniture of the home, it would be hard to find very many articles which have not undergone some chemical process during their production.

The health of its occupants is another important factor of a happy and comfortable home. Many useful drugs and anesthetics have been produced as a result of chemical research. Quinine, acetanilide, aspirin, purgatives, tonics, anesthetics and disinfectants are all drugs which chemists have produced for the betterment of life.

Much work has been spent on the purification of water so that disease germs may not be taken into the human body. The processes of purification have nearly been perfected. Then there is the matter of sewage

disposal, which a few years ago gave us considerable thought, but which has been solved by chemists in their production of the septic tank and the use of chemicals which cause the decomposition of the organic matter in the sewage.

In this discussion it has been possible merely to suggest the close relationship of chemistry to the home. Today man marvels at the wonders created by chemists, and the outlook of tomorrow is brighter than ever before in the history of man, for chemistry is only in its youth. May God continue to enlighten the world through its chemists.

Chemist Analyzes Tuberculosis Germ. Chemical analysis of the germ that causes tuberculosis has led to the discovery of a new type of compound, a phosphorus-containing fat, which has peculiar biological properties, according to Prof. R. J. Anderson of the department of chemistry at Yale University.

The tuberculosis bacterium is unique among single-celled organisms in being the possessor of a waxy covering which renders it highly resistant. Prof. Anderson extracted eight pounds of the germs with a mixture of alcohol and ether to dissolve out this waxy coating. He obtained a pound of wax, half a pound of fat proper, and half a pound of phosphatide or phosphorus-containing, fat-like substance. The last material, to which he has given the name phosphosucride, is the most unusual constituent of the germs. It has been shown to contain phosphoric acid, a sugar, and fatty acids. "This compound differs from all other known phosphorized fats," Prof. Anderson stated. "It may be expected to have peculiar biological properties."

While the biochemist is busy probing the formula of the phosphosucride, other investigators are studying it biologically at the Rockefeller Institute for Medical Research, New York City, to determine to what extent the destructive powers of the tubercle bacillus are due to this element in its makeup, and whether once identified, it will be of service in the treatment or prevention of the disease.

Other chemists in an analogous way have obtained specific chemical compounds from pneumonia bacteria, which show promise when applied clinically.—*Science Service*

Coffee Speeds Brain Motor, Says Psychologist. Coffee is the only drug that increases mental efficiency without a following decrease in efficiency, according to Dr. John B. Watson, well-known psychologist of the behaviorist school.

In his own case, Dr. Watson says, he finds he does his best writing at night with the stimulation of coffee. One cup makes him fairly alert. But after taking two cups he can put in five hours or so of strenuous mental work at a time when most people are thinking of rest or recreation.

The immediate reaction to coffee, he holds, is a marked increase in mental vigor. After this initial spurt of energy has worn down, the effect of the coffee is still apparent in that the mental efficiency remains at a level slightly higher than normal. At no time is there mental depression. And in causing no decrease in efficiency coffee, he claims, has a unique position.

Taking tobacco as an example, he explains that, while smoking causes mental exhilaration for the first five minutes, the exhilaration is followed by a noticeable depression before the efficiency again settles at a normal level.—*Science Service*

THE RELATION OF CHEMISTRY TO NATIONAL DEFENSE*

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Defense is that which protects. Chemistry is so bound up in every phase of national as well as individual protection that the including in a paper of this kind of even a majority of its various phases is impossible. Obviously, anything that betters living conditions, improves public health, and mitigates the devastation of disease builds up a fighting force whose chances of victory are just so much enhanced. Chemistry, in coöperation with medicine, does all of that in ways too numerous to mention.

Certainly nothing is more essential to an army than food, clothing, shelter, and ammunition. In the last war, cotton played a large part in meeting the demand for these; and chemistry, in turn, played an important rôle in the cotton industry. Most of the fatty foods used in the war came from cottonseed oil. Much of the clothing was cotton; and equipment of artificial leather and felt was derived from cotton linters. Cotton linters filled the mattresses; and cotton was the chief constituent of the tents and bed clothing. Glycerides and cellulose, chief sources of explosives, were obtained from cotton oil and linters.

Now the relation of chemistry to this all-important cotton industry is close. Chemistry controls the oil mills, determines quality through analysis, and develops the edible products for human and live-stock consumption. This one example demonstrates the multiplicity of ways in which chemistry is indirectly bound up with the national defense.

In a number of former wars, fatalities due to disease have been more numerous than those due to bullets. Any development, therefore, which lessens such a danger and furthers the physical welfare of the soldiers is an integral part of defense. The recent progress of the United States in therapeutics and pharmacology is one of which we may justly be proud; and this progress has been largely due to chemical development. Improvements in antiseptics are apparent in such advancements as mercurochrome, used in the treatment of blood poisoning. Chemistry has made possible the development of anesthetics of greater efficiency and purity, an example of which is procain, a harmless, non-habit-forming, though powerful, drug.

By the isolation and identification of one of the constituents of tuberculinic acid a start has been made toward the control of tuberculosis, the scourge of men subjected to extreme exposure. The use of epinephrine in treating pneumonia, a constant threat to soldiers, has also been of great value by reducing the dangers of heart failure. Valuable weapons in combating syphilis, of which there are over 10,000,000 cases in the United States, have been found in atoxyl and salvarsan which last is also of great

* Prize-winning college essay, A. C. S. Prixe Essay Contest, 1926–27.

value against malarial parasites. In addition to all this, a cure for leprosy has been perfected by combination with ethyl alcohol of acids obtained from chaulmoogra oil but lacking in its objectionable features. Such a remedy allows the army to maneuver, with less danger than formerly, in lands infested with leprosy. All this demonstrates the necessity in our defense of constant research and coöperation between chemistry and medicine.

One of the relations of chemistry to the clothing problem of the army has been mentioned above in connection with the cotton industry. In addition to this, leather used in harness, saddles, ammunition belts, puttees, shoes, and many other articles is tanned by chemical processes. Also the utilization for army equipment of chemically synthesized leather is extensive. The deterioration of this army equipment has been greatly retarded by the recent discovery of a gas made from sodium cyanide and sodium chlorate, which not only kills rodents but absolutely protects textile goods from the ravages of moths. Thus, chemical development is responsible not only for the clothing itself but also for its preservation.

The time-worn adage to the effect that an army fights on its stomach is not only figuratively but literally true in this age of trench warfare. But whatever way you take it, there wouldn't be much fighting were it not for the chemistry of food. Chemistry has done inestimable service in its improvement of canned goods and its development of hydrogenated oils.

Canners support our civilization. They made possible the sending of our soldiers to Europe in the late war. Due wholly to the work of chemists, canned goods can now be provided that include all the necessities of a correct diet. In time of war, when canned goods comprise the chief food supply of the soldiers, the importance of this is patent.

Hydrogenation has also proved a great boon to the soldiers. Vegetable oils of the type of cottonseed can be made into edible fats of remarkable consistency by the addition of one per cent, by weight, of hydrogen. Moreover, by the addition of hydrogen to the unsaturated glycerides, the bad odors of certain oils are eliminated. Butter substitutes, chemically compounded, are of enormous value to an army not only because of their slow rate of deterioration, but also because of the readiness with which they can be obtained.

The very accessories of war are indebted to chemistry for their utilization. One example will suffice to illustrate this indebtedness. The airplane undoubtedly was one of the most potent factors in carrying on the World War. Chemistry, as usual, is interwoven with this invention in a number of ways. Duralumin and manganese bronze are important alloys to the airplane industry. Cellulose acetate sheets are of use as airplane wings. Acetone is in great demand as a constituent of the "dope"

used on airplane wings as well as for the manufacture of cordite. A fermentation process for its production, superseding the former method of deriving it from calcium acetate, has increased the facility with which it may be obtained. The enormous amount of gasoline that was used, not only in airplanes but in tanks and trucks as well, was made possible by a process known as "cracking." This consisted in decomposing heavy, non-volatile hydrocarbons by heat and pressure.

Further applications of chemistry to war accessories lie in the development of such things as glass for telescopes, periscopes, spy-glasses, etc., and chrome steel for use in manufacturing projectiles, for gun screens, steel helmets and armor, and equipment of battleships.

As for munitions, modern artillery and its ammunition owes its very existence to chemistry in some form or other. Explosives, for instance, are compounds with nitrogen as the main element. Nitric acid is the basis of all commercial explosives. Cellulose hexanitrate, made by nitrating cotton, is of great importance as a filler for mines and torpedoes and also as a basis for such smokeless powders as cordite. The United States produces annually 300,000,000 pounds of explosives containing this compound. But since explosives must be comparatively safe to handle as well as capable of exploding, percussion caps of mercuric fulminate are employed, to insure their detonation at the proper time. These few illustrations emphasize the complete control that chemistry exerts over modern warfare.

To the average person, a reference to the relation of chemistry to war and defense immediately brings to mind the thought of gas warfare. This is entirely natural because gas was an immense factor in the last war and merits greater consideration in plans for defense than any other one thing.

The use of gas as a war weapon was inaugurated by the Germans, on April 22, 1915. Its success was instantaneous, and, had the Germans followed up the advantage gained by their first gas attack, it is generally conceded that they could have broken through to the ports and won the war.

Of course, the Allied forces frantically hurried means for protection and as a result chemists evolved the gas mask, employing cocoanut charcoal as an absorbent. When we realize that the Allies would soon have had to surrender, had it not been for this protective device, we begin to appreciate the work of our trained chemists.

A great, though irremediable, objection to these masks lay in the fact that the enforced wearing of them was a great hindrance to proper maneuvers. Their weight and bulk hampered the action of the soldiers to such an extent that the efficiency of a given body of men was reduced by 25 to 50 per cent—obviously a vital factor in a crisis.

To return from the protective appliance to the gas itself, Germany

employed four main types of gas: tear gas, of which chloropicrin is an example; sneezing gas, such as diphenyl-chloroarsine; toxic gas, as chlorine and phosgene; and "mustard" gas. The extreme flexibility of chemical products and their connections with peace industries is demonstrated by the use of chlorine in such beneficent guises as chloroform, sodium hypochlorite (used for the irrigation of infected wounds) as a disinfectant for water. Phosgene, too, is in demand in time of peace, being a valuable chemical in the dye industry. Used as a war gas, however, it is so poisonous that a concentration of 0.3 milligram in one liter of air is toxic to animals.

Of all the gases used, mustard gas was the most efficacious. The mask was of little protection against this vesicant gas, which attacked all parts of the body. It penetrated the skin and was absorbed by the tissues, hydrochloric acid being formed as a result of hydrolysis. Although the death rate of this gas was small, the casualties were enormous and great gaps were created in the Allied lines. The first time it was used it affected about 3000, most of whom were hors de combat for months. It was extremely persistent, and, because of its relatively slow activity, ground sprinkled with it remained unsafe for days. By its use, any given open spaces of a country could be made as valuable as those bristling with formidable engineering construction. On more than one occasion, when the Germans expected an attack, they attempted to create an impassable zone in front of the Allied lines by the use of mustard gas.

Mustard gas was used chiefly in gas shells, which, in 1918, comprised 80 per cent of all the projectiles used by the German army. We can readily see the extreme importance of gas warfare, when we realize that it was largely due to this that the Germans were enabled to keep the initiative well into 1918; that in the great Marne offensive of the same year they depended largely on gas; that the success of their offensive against Italy, in 1917, was attributed to gas; and that the final Allied success was largely due to this weapon. In view of these facts we cannot but accept the obvious conclusion that chemical warfare played a very important and ever increasing part in the great World War.

The great importance of chemical warfare having been established, the next consideration concerns its future possibilities; for if its expansion is doubtful and its importance in future wars likely to decrease, extensive plans for defense against it are useless.

As we have seen, the gases of chemical warfare are extensively utilized in peace and, therefore, are always at hand for war. New potential war gases will inevitably evolve as a natural result of scientific research. Moreover, the development of poisonous gases is so closely connected with the dye industry that detection of the former is, practically, impossible. Chemical warfare products are, in some cases, identical with

those of the organic chemical industries. This flexibility of organic chemistry is an extremely important consideration and should be fully realized. In the words of Efisio Mameli, Italian chemist and professor in the University of Pamia: "Since vast military arsenals are condemned, the surprise element in the future will be furnished by private industry, which cannot be restricted or abolished, since it lies behind all scientific and economic progress."[1]

Thus, as already indicated, new war chemicals are likely to be discovered without any conscious effort in that direction. Chemical warfare is in its infancy; and, probably, every nation of leadership and foresight has, in reserve, concealed weapons of its own.[2] The organic chemical industry can swiftly and silently mobilize for war; and its possibilities for surprise are such that its importance as regards future wars can hardly be over-estimated. Its power is so great that any nation able to spring a surprise similar to that of the Germans in 1915, only this time with decisive results, would obviously have the world at its mercy.

America, soon after her entrance into the war, manifested the importance she attached to chemical warfare by the establishment, within the War Department, of a Chemical Warfare Service whose duty it was—and is—not only to keep pace with but to keep in advance of the rapid progress of this new method of waging war.

But if the safety of any given country and the protection of its citizens is to be insured, that country must do more than establish departments and erect arsenals. First and foremost, since the industries based on synthetic organic chemistry are so closely allied to chemical warfare, those industries must be fostered and the civil population educated as to their importance. This applies to every nation which hopes to retain or acquire a position among the leading powers of the world. In this twentieth century, well-developed chemical industries afford a better protection than mighty navies and imposing fortresses. It is obvious that, had the Allies (or America) possessed a flourishing dye industry at the beginning of the war, Germany's gas success could never have materialized and thousands of lives would, thereby, have been spared.

For American protection, General Fries, head of the Chemical Warfare Service of America, in addressing the American Chemical Society, advocates the use of Edgewood Arsenal as a peace dye plant and shows that, by reliance on a normal chemical industry, the United States would be able to manufacture poisonous gases for use in case of war more rapidly

[1] "Chemistry and National Defense," *Living Age*, **321**, p. 1034.

[2] Hamilton Fish, Jr., Congressman from New York, in a letter made public January 6, 1927, says, "New forms of odorless and deadly gas *have been discovered* (the italics are mine) which will make the more harmless varieties used ten years ago mere childish play."

and efficiently than by any other means. He continues to say that the mobilization of industry for that purpose will be one of the greatest guarantees for world peace.

Thus we see that scientific research is all important[3] in plans for national defense; and with this must be included industrial development and military application. Such a course is imperative if we wish to maintain our present position "in the struggle for commercial independence and supremacy"—an independence which is the very crux of national defense. In 1925, Japan proposed the expenditure of $2,500,000 for building chemical laboratories and equipment. Less than a year later, Major-General Fries announced that appropriations, in recent years, for his section had been far too small. This condition must be remedied if the safety of posterity is to be made more nearly indubitable. The public at large must be educated to the dangers of inertia; and interest in and coöperation with the American Chemical Warfare Service should be developed. Chemical warfare favors the most scientific and industrially developed nation. Let us guard lest our boast of world supremacy in such matters prove to be but a braggart's dream.

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[3] General Fries, in the *Journal of Industrial and Engineering Chemistry*, 1920, says, "No other invention since that of gun powder has made so profound a change in warfare as gas is making or will make in the future."

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New Remedy for Diabetes Announced. Clinical tests of a new drug, myrtillin, expected to be of considerable supplementary value in the treatment of diabetes, were announced to the American Medical Association at Washington, recently, by Dr. Frederick M. Allen, director of the Physiatric Institute at Morristown, N. J.

Dr. Allen stated that while myrtillin was in no sense a substitute for insulin, it does produce some of the beneficial effects of the better known drug without some of its greatest disadvantages. It can be taken by mouth instead of by injection and is entirely harmless, never producing an unduly low sugar content in the blood, but it has the disadvantage of not having the prompt and powerful action of insulin and is not successful in all cases. . . . .

This new preparation was discovered by Dr. Richard R. Wagner, chief of the chemical department of the Physiatric Institute, who has also worked out the methods of producing it.

The leaves of the blueberry or huckleberry are the source of myrtillin, but it can be obtained from the green leaves of certain varieties of plants, especially the myrtle family, from which the name of the substance is taken. . . . . —*Science Service*

Malaria Found Best Help for Paresis Victims. Killing off one disease through the action of another is a medical method of increasing interest. Treatment of the paralytic forms of syphilis with inoculations of malaria has had a three years' tryout at the Mayo Clinic and was pronounced the most valuable method used thus far, by Dr. Paul A. O'Leary of Rochester, Minn., at the meeting of the American Medical Association recently.

Many more years of observation will be necessary, however, Dr. O'Leary emphasized, before it will be justifiable to speak of the "cure of paresis." Results must now be estimated in terms of arrest or remission, he said, as shown by the ability of patients to resume their former mode of living. The malaria treatment is not without risk as the mortality of five per cent recorded by Dr. O'Leary shows, but he believes that this rate compares favorably with that of any untreated group, observed for the same length of time.

The greatest improvement was noted where the malaria was introduced early in the course of the paresis but striking results were cited by the Rochester specialist in cases of four years' standing.—*Science Service*

THE RELATION OF CHEMISTRY TO THE DEVELOPMENT OF THE COTTON INDUSTRY*

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It may not be too bold to say that the cotton industry is the greatest single industry in the whole world, if the cultivation, manufacture, commerce, and uses of all its products are considered. Cotton is the fabric of civilization. It has been a factor in building nations and in rending them apart. Cotton has great possibilities both for fostering international peace and promoting world war. As the basis of nitroglycerin it is a great destructive force; as the world's greatest trade commodity, it becomes a factor for universal peace. Its economic importance is far beyond numerical expression, for while the total crop of the world is approximately ascertainable, the effect of cotton upon the commercial and social relations of mankind is too far-reaching for estimation. If for a single year, not an acre of cotton should be planted in America, millions of people would be unemployed, the dress of the whole world out of order, and nearly every phase of human endeavor would be affected.

The cotton plant through the wizardry of chemistry is now contributing to the four outstanding needs of humanity, namely, clothing, food, shelter, and ammunition. It, therefore, seems that the relation of chemistry to the development of the cotton industry should be a subject of universal interest.

We first consider the chemist in relation to cotton culture. Of the thirteen elements essential to plant growth (hydrogen, oxygen, nitrogen, chlorine, potassium, magnesium, calcium, iron, sodium, carbon, sulfur, phosphorous, and silicon) the three "critical" elements—nitrogen, phosphorous, and potassium—must exist in the soil in sufficient quantities and in the right proportions to produce maximum cotton crops. Through soil analysis the chemist can determine the elements lacking and can supply these in the form of economical plant food and chemical fertilizers.

In the growing of cotton, favorable soil conditions are equally as important as plant food. Again we are indebted to the chemist for our knowledge of the physical condition of the soil which deals with processes of oxidation, prevalent microörganisms, basicity, acidity, ventilation, and so forth. Intelligent utilization of the soil for crop production is one of the triumphs of the applications of chemistry in industry. The beginnings of intelligent agriculture date from the time when the chemist was first able to analyze both plant tissues and the soil from which these must be built. It may properly be said that chemistry offers the fundamental scientific basis for a sound and permanent agriculture.

* Prize-winning college essay, A. C. S. Prize Essay Contest, 1926–1927. Miss Greenhill's essay was accompanied by a scrap-book, which it is, of course, impossible to reproduce here.

It has been estimated that every three hundred pounds of lint cotton removes from the ground 35.14 pounds of potash, 12.8 pounds of phosphorous, and 42.37 pounds of nitrogen. We realize that the possibility of maintaining soil fertility must be largely by the applications of chemicals in the form of fertilizers. Since a greater quantity of fertilizer is used for cotton than for any other crop, one may say that the salvation of the Cotton Belt depends on securing cheap and efficient chemical fertilizers. The development of artificial fertilizers has brought many problems to the chemist. Perhaps the two greatest of these are the production of cheaper nitrogen and an independent supply of potash.

Just as the chemist has played the important part in the development of commercial fertilizers and in the working out of standard formulas for these, likewise control chemists have rendered important and useful service to the consumer in protecting him from fraudulent fertilizers. It has been estimated that chemical examination of insecticides and fungicides has been a means of saving billions of dollars.

The chemist's work is not completed when, by conditioning the soil, he has promoted the rapid growth and fruitage of the cotton plant. During the pitiless heat of southern summers, through the march and countermarch of serried enemies, the cotton must battle for its life. Disease and insects, terrible in their might, take an annual toll inestimable in dollars, in blasted hopes, and human despair. If Job were a character of today he would be a cotton farmer. The messengers coming to tell him of his troubles would report boll weevil, boll worm, pink boll worm, army worms, navy worms, cut worms, leaf bugs, lice, fleas, red spiders, root rot, wilt, and yellow leaf blight. Chemists and entomologists, toiling in their laboratories to discover means of checking these foes, which at times seem to threaten the extinction of the cotton industry in the South, have provided insecticides and chemicals helpful in combating plant diseases.

Not since the lice and locusts descended upon Pharaoh has the trespass of any insect caused such loss as has the boll weevil. Cotton growers are especially grateful to the chemist for the success of calcium arsenate in the control of this beetle which, with no prejudice in favor of race suicide, raises over twelve million offspring in one season.

The recent appearance of the flea on the young cotton plants has caused tremendous excitement. In an incredibly short time chemists came to our aid with sulfur to combat this new pest. The fight against insect pests and fungus diseases is primarily a case for chemical warfare. It is impossible to conceive of the magnitude of the loss from these two causes throughout the country. Because of the added expense to crop production from repeated sprayings resourceful chemists are now working on combination sprays to exterminate different kinds of insects simultaneously. This will be another great contribution of chemistry to industry.

Not alone for his aid in the cultivation of cotton are we indebted to the chemist. The science of chemistry is always beckoning cotton on into new bypaths. In the refinements of clothing cotton undergoes a bewildering metamorphosis. It masquerades in the form of velvets, brocades, fleece-lined "all-wool" underwear, glossy mercerized stuffs, wool hats, artificial silk, and linen. Touched with the artistry of the textile chemist and colorist, plain cotton fiber is transformed and has become protean, brilliant, astounding! The bleaching, dyeing, printing, mercerization, and finishing of textile materials requires a thorough knowledge of chemistry and involves the use of a great variety of chemicals and chemical reactions. Less than eighty years ago dyeing was a tedious business, the dyes depending chiefly upon vegetable matters, but in 1856 a chemist named William Henry Perkin discovered the first of the so-called coal-tar dyes. Since this time more than fifteen hundred different dyes have been made, giving us brilliancy of color and an almost unlimited variety of shades.

To John Mercer belongs the credit of originating one of the most successful commercial methods for creating a high luster on the cotton fiber. Mercerized cotton is formed by stretching yarn on a frame and submerging it in a solution of caustic soda. This causes the fibers to swell and to a certain extent lose their twisted structure. Thus they become as silky and beautiful as the locks of Lucrezia Borgia.

Bleaching is another chemical process which contributes to the attractiveness of textile materials nearly as much as the addition of luster and color. For the most part bleaching is an oxidation process. Chlorine, in the form of hypochlorites and certain peroxides, usually hydrogen or sodium, is most commonly used as an oxidizing agent.

For thousands of years the cultivation and manufacture of the cotton plant were for its fiber alone, but through the cunning of chemistry the cotton plant now yields a double crop. One of the romances of chemistry is the story of the discovery and development of the manifold uses of the cottonseed, soft cocoons wrapped in silky gray fur, but filled with magic power. Before these down-wrapped seeds revealed their miracles they were considered worse than waste, a nuisance. Within the space of half a century the chemist has developed from this little seed an industry which has added more than one hundred and fifty million dollars annually to the value of the cotton crop while the value of the finished by-products is vastly greater. The cottonseed yields four main products, namely, linters, hulls, oil, and meal, and from each of these in turn through chemical processes are made innumerable useful articles.

From cellulose, a product of the linters, some of the most spectacular triumphs of chemistry have been achieved. By the discovery of a solvent for cellulose a perfect counterfeit of silk has been made. Thus

Cinderella Cotton is invited to the ball and is suitably arrayed to dance with the prince. While artificial silk was originally intended as a false substitute for real silk, it has, through chemistry and modern methods of manufacture and adaptation, attained a position of its own in the textile field. It is amazing to know that in December, 1925, a St. Louis wholesale dry goods company purchased three hundred and eighty thousand dollars worth of a single number of artificial silk. There are now in use four main processes for the manufacture of artificial silk. These employ in common similar manufacturing procedures and use cellulose as raw material. By forcing the semi-liquid cellulose through minute openings into a solution which hardens it, silk-like threads are formed. These are then woven into the desired fabric. The dissolved cellulose can also be poured on rollers and made into cloth in sheet form without necessitating weaving. This method of cloth manufacture may revolutionize the whole textile industry. The artificial silk industry, although still in need of chemical research, is well established and approaching its fulfilment. This new textile product is more sanitary, has a greater affinity for dyes, and retains white color better than real silk. When a fiber having greater elasticity and water-resisting properties is produced, unlimited applications will be created for this product of science.

Among other products of cellulose are synthetic plastics. From celluloid, which is one of these, is made a dazzling, bewildering stream of novelties. Other plastics are ivory pyralin, phonograph records, and photographic films. Photography, especially in the motion picture industry, uses millions of miles of nitrocellulose film a year. From pyroxylin, which is a basis for plastics, are manufactured varnishes, coating for metals, water proofing and artificial leather. In the manufacture of artificial leather chemistry has again created a new industry. This product of nitrated cotton and alcohol has been used in enormous quantities since the popularization of the automobile. Millions of square feet of artificial leather annually go into the construction of motor vehicles. Without such material for cushions and curtains the automobile business would be sorely hampered.

Cellulose plays a double rôle when transformed into paper and gun cotton. "It appears like Brahma in two aspects, Vishnu the Preserver and Siva the Destroyer." When cellulose is prepared into paper which has made democratic education possible, we see it in its beneficent aspect. When cellulose is treated with nitric acid we get gun cotton, which shows its maleficent aspect.

From the hulls, which constitute about half the ginned seed, the chemist, great economist that he is, has prepared paper and household utensils. The hulls are also used for cattle feed, and as a fertilizer they are rich in potash.

Second only in importance to the nitrogenous foods are the fats. In the utilization of cottonseed oil for food the vegetable kingdom rivals the animal kingdom. After this oil is bleached with fuller's earth, filtered, and deodorized, it is mixed with a small percentage of hydrogenated oil so that it looks and tastes like an animal fat, and thus competes with lard. The process of hydrogenating or hardening oils is probably the most important of recent chemical discoveries in the field of food production. All of the refining methods and subsequent manufacture of lard compounds, oleomargarine, butter substitutes, salad oil, etc., are entirely results of chemical ideas and experiments. It can probably be stated without contradiction that the cottonseed products industry is more largely the result of chemical investigation than any other of our large industries.

The fourth product of the cottonseed is the meal or cake. It is used chiefly for stock feed and fertilizers. The advice of the chemist in the use of cottonseed meal for cattle is important because of its highly concentrated protein composition. The meal is one of the most satisfactory forms of nitrogen that can be used in making mixed fertilizers for the common farm crops. It is rich not only in nitrogen but also contains considerable quantities of phosphoric acid and potash.

To return to the subject of the cotton plant as a unit, the multifariousness of its products and its world-wide demand are well shown by the North Carolina professor who says that we get up in the morning from a bed clothed in cotton; we let in the light by raising a cotton window shade; we wash with soap made partly with cottonseed oil products; we dry our faces on a cotton towel; we array ourselves chiefly in cotton clothing; the "silk" which we wear is probably a product of cotton waste; at the breakfast table we do not get away from cotton; "cottolene" has taken the place of lard in the biscuit we eat; the beef and the mutton were fattened on cottonseed meal and hulls; our "imported olive oil" has more likely come from a Texas cotton farm than from an Italian villa; our butter is perhaps a product of the Southern cottonseed; the tonic we take is possibly extracted from the cotton root; our morning daily is printed on cottonwaste paper and even in the skirmish it tells about the contending forces were clothed in khaki duck, slept under cotton tents, used high explosives of which cotton was an essential, and when at last the war had done its worst, surgery itself called cotton into requisition to aid the injured and dying.

Cotton is the world's universal commodity. It would be hard to find a human being in all this swarming planet who does not use cotton in some form. The Laplander barters a bit of fur for a cotton wick. The tropical savage with a passion for adornment bedecks himself with cotton novelties. Cotton blooms into delicate forms of flower-like beauty for pampered femininity. Through the transforming science of chemistry it

plays hide and seek in a hundred freaks and fancies and streams fan-like into scores of new industrial channels.

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New Use for Wheat Straw. The wheat growers of the Central West are at last about to realize a dream that they never believed would come true. They are to have an outlet for the waste straw that is left over after every harvest. The custom has been for the farmer to apply a lighted match to the straw stacks on some still night, as the easiest and quickest way to get rid of them.

Because of the long, tough, fibrous nature of wheat straw it would hardly be eaten by a starving animal. Its low content of nitrogen, phosphorus, and potash made it of negligible value for fertilizing purposes and its resistance to the corroding action of the elements made it a nuisance when the farmer began preparing his land for the next crop.

The fact that straw can be converted into insulating board of the highest quality is one of the recent and valuable discoveries of science. Tests have shown that straw as insulating material has a value of more than 10 per cent over other fibrous growths, such as cornstalks, which were found unsuited for the purpose of good insulation. It also showed remarkable tests for structural strength.

The first mill to engage in the manufacture of straw into insulating boards is now building at St. Joseph, Missouri, and will represent the latest developments in pulp and insulating board equipment. Its proximity to the wheat fields of Kansas, Missouri, Nebraska, and the Dakotas insures a never-failing supply of raw material and gives to the farmers of this region an outlet for a waste product that will add many dollars to credit at the bank.

THE CHEMISTRY OF PHOTOGRAPHY. III. DEVELOPMENT OF NEGATIVE AND POSITIVE IMAGES

S. E. Sheppard, Eastman Kodak Co., Rochester, New York

It has been already emphasized that the outstanding feature of modern photographic processes is the combination of a process of development with the formation of a latent or invisible image. Consequently processes of development are of equal importance with the formation of latent images. In fact it was the discovery of a particular process, alkaline development, which largely made possible the use of the gelatino-bromide plate.

The essential importance of a photographic development process consists in its availability to multiply the effect of the primary photochemical reaction hundreds or thousands of times, so that an almost infinitesimal change can be made to give a substantial amount of photographic deposit. In this sense, it may be pointed out, photographic development resembles a large number of "dark" reactions which continue a primary photochemical reaction. While there are certain processes of development, such as the use of hot water to dissolve away unhardened gelatin or glue in bichromated colloid processes, which do not fall under the silver processes, by far the most important development processes depend upon the reduction of silver to a metallic state.

Physical and Chemical Development

A developing solution will then in general be a reducer for silver salts. A distinction was made rather early in photography between so-called physical development and chemical development. The early processes of calotype and wet collodion involved the use of a developing solution containing a soluble silver salt, an acid, and a reducing agent. A typical example is the combination of silver nitrate, acetic acid, and ferrous sulfate. Such a combination was used in the development of wet collodion plates. In 1862 Russell discovered that it was possible to develop an image in collodion dry plates with an *alkaline* solution of pyrogallic acid without the addition of soluble silver salt, which would indeed have been immediately reduced in the alkaline bath. This discovery only acquired its real significance when the gelatin dry plate was invented. The somewhat misleading terms, "physical" and "chemical" development were applied, respectively, to the process using a developer containing a soluble salt, and to that using a developer containing no silver salt, but which reduced the silver halide of the emulsion layer itself. There is, of course, no real difference in the chemical sense between the two, but photographic terminology is full of chemical misnomers.

In the various modern procedures of development it is probable that

we have actually a continuous transition between processes in which the solid silver halide grain is reduced *in situ* and substantially in the solid phase, and processes in which the reducible silver, either as free silver ions or complex silver ions, is entirely in solution and is reduced in the solution state. In a study of the chemical dynamics of development, the phenomena may be regarded from two points of view, namely, according to the reduction potential of the developer or according to the silver halide solubilizing capacity of the developer. The particular characteristics of a given developer are probably determined by the balance of these two factors. In so-called physical development the solvent capacity of the developer plays no part, because the solution contains a soluble silver salt, while in certain extreme types of so-called chemical development, the solvent action of the developer may be almost nil. In any case the fundamental chemical reaction consists in the reduction of ionic to metallic silver, representable by the following equation

$$Ag^{+} + \overline{\overline{R}} \rightleftharpoons \underset{\text{(met.)}}{Ag} + \overline{R}$$

The metallic silver thus formed is built up at first around the latent image specks in the silver halide grain, and the process may continue until the whole of the grain is reduced to the metallic state. A typical developing solution will consist of the following:

a reducing agent, such as pyrogallol,
an alkaline accelerator, such as sodium carbonate,
a preservative, such as sodium sulfite,
a restrainer, as potassium bromide,

the whole being dissolved in water. In making up the solution the sulfite should be dissolved first, and then the reducing agent, since the sulfite is acting as an antoxidizing agent to protect the reducer from aerial oxidation.

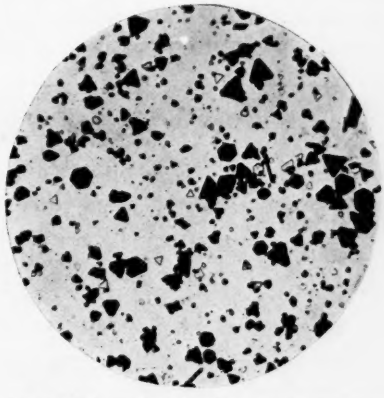
Micro-Chemistry of Development

When the developing solution is flowed on the plate or film, we may distinguish a number of phases in the operation, some occurring simultaneously, others successively. To begin with, the developing solution has to swell the gelatin and the reducing ions have to diffuse into the film, the more swollen the gelatin the less being the resistance to diffusion. Usually the gelatin will require ten to fifteen minutes before the actual resistance to diffusion has sunk to that of pure water, but long before that the diffusivity has become at least 70 to 80% of that in water. It appears very likely that the rate of diffusion does largely determine the general rate of development, because when layers of gelatino-silver bromide which are only one grain thick are developed and examined microscopically,

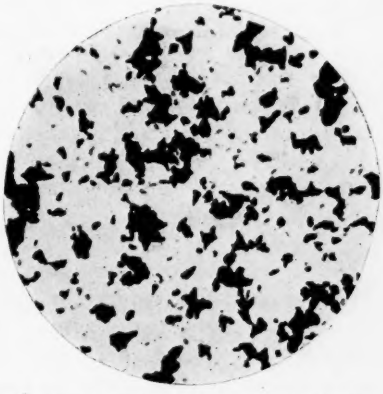
all the developable grains appear to be completely reduced within three to four minutes in a fairly dilute developer. However, the large differences in the velocity and course of development with different developers show that the process cannot be regulated by diffusion alone, but must involve very specific chemical factors. We have written the general equation for development,

$$\overset{+}{\mathrm{Ag}} + \overline{\overline{\mathrm{R}}} \rightleftharpoons \underset{(\mathrm{met.})}{\mathrm{Ag}} + \overline{\mathrm{R}},$$

as for a reversible reaction. In the case of development with ferrous salts, in a relatively acid solution this is substantially the case. In consequence of an equilibrium tending to be reached, such a developer is unable to reduce silver halide grains having less than a certain amount of latent image, and such developers give a lower speed than the alkaline developers in which the reaction is only *de jure* but not *de facto* reversible.



Developed grains showing little change of form.



Developed grains showing large change of form.

FIG. 1

We shall return to this again in a moment when considering the reduction potential of developers. In the meanwhile it can be stated from the microscopic study of the process that in an ordinary negative emulsion the larger grains (see Part II of this series, "The Latent Image"), which on an average are the most sensitive, tend to be developed first. On an average, with constant time of development and increasing exposure the number of grains developed increases with the exposure, while the average size of the developed grains tends to become less with increased exposure, this being due to the selective action of the exposure. For the shorter exposures the developed grains are chiefly near the surface, while the lower layers fill up more with developed grains as

the exposure increases. With constant exposure and increasing time of development both the number of grains and the average size of developed grains tend to increase to a limit dependent on the exposure. The reduction of the grains may, under certain conditions, leave the crystalline shape of the grain unaltered, but more generally leads to a distortion and irregular spreading. While Fig. 1 shows something of the variation of individual grains produced by development, Fig. 2, which shows cross sections of

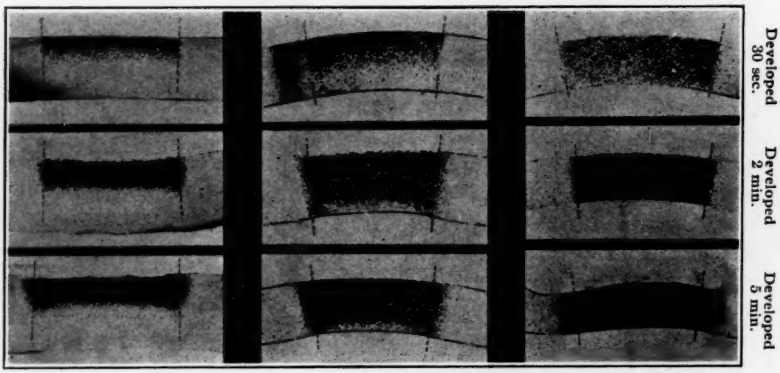


FIG. 2.—Photomicrographs showing effect of exposure and development in producing silver.

film at different stages of exposure and development, gives an idea of the progress of the average. The size of the individual grains of silver depends both on the original size of the silver halide grain and on the kind of development.

The Chemical Nature of Organic Developers

Not all reducing agents are suitable as photographic developers. Some are so powerful that they will instantly reduce the silver halides without relation to a preceding exposure to light. Others are too feeble even to effectively reduce the exposed silver halide. This "power" of a reducing agent is more properly characterized as its reduction potential, which may be taken as proportional to the e. m. f. developed in a reversible cell of the following type.

Pt	$\overline{R} : \overline{\overline{R}}$ aq.	Neutral salt bridge	NaCl : HgCl aq.		Hg

In case of alkaline solutions of organic reducers, such a cell cannot be constructed, because the primary oxidation products of the reducer are

not stable but are decomposed by side reactions. Extensive investigations by A. and L. Lumière, and by Andresen have shown that certain fairly general rules are applicable in defining the constitution of organic development agents. Thus, practically all organic developers are aromatic derivatives and restricted to ortho- and para-substituted diphenols, diamines, or aminophenols; that is, the arrangement of the molecules belongs to one of the types shown below.

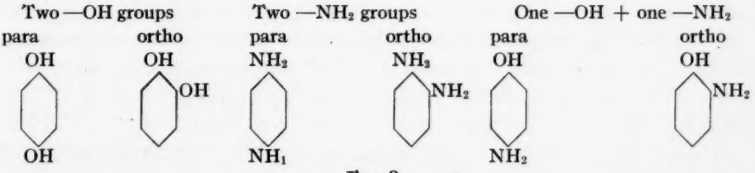
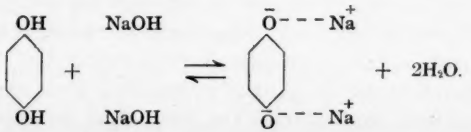


FIG. 3

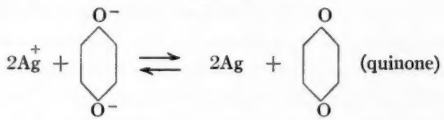
Instead of a benzene nucleus, we may have a naphthalene nucleus and various other substituents may be present in the ring, with definite effects on the developing properties. It was at one time supposed that the difficulty of formation of metaquinones by oxidation was the chief reason for this structure of organic developers, but Homolka has found that while symmetrical trihydroxybenzene is not a developer, it becomes one if the trimethyl body is formed,

(not a developer) (developer)

which he attributes to the prevention of tautomeric change from the enolic benzene derivative to the ketonic derivative of a hydrobenzene. The function of the alkali in the developing solution is perhaps also connected with this. With increasing concentration of alkali, that is, of hydroxyl ion, the velocity of development increases to a maximum. This may be attributed firstly to displacement of the tautomeric equilibrium in favor of the enolic form and next to the formation of ionized salts of the reducer. For example, with hydroquinone, the actual reducer is probably the ion $C_6H_4O_2^{--}$ formed by the reaction,



and the primary reaction in development is,



However, although quinones and imino-quinones are probably the primary oxidation products in alkaline developers, these bodies are quite unstable in the alkaline solution. The quinone not only undergoes some type of peroxide formation from aerial oxygen in an alkaline medium, but in the presence of sulfite is converted first into hydroquinone mono-sulfonic acid and later into di-sulfonic acid. The introduction of the acid sulfonic group, however, greatly lowers the reduction potential and the developing power. In the absence of sulfite, condensation of the reaction products to resinous bodies and to coloring matters takes place, which would lead to a strong stain over the plate, but the presence of sulfite greatly reduces the formation of these bodies, and also reduces their adsorption to the gelatin and to the silver of the developed image.

An interesting and important side reaction consequent on the autoxidation of the developer by atmospheric oxygen is the so-called "aerial" fog produced with certain developers when the developing film is exposed to the air during the process. Investigations by J. I. Crabtree and by E. Fuchs have shown that this aerial fog which is particularly notable with hydroquinone, is possibly due to a reaction luminescense producing light at the surface of the film capable of producing a latent image. It may be greatly reduced by adding dye desensitizers to the developer, while it is increased by the presence of traces of copper salts, which catalyse the autoxidation.

Influence of Soluble Bromide and Reduction Potentials

It has been stated that in consequence of the actual irreversibility of reduction with alkaline developers that e. m. f. measurements cannot give reliable information on their reduction potential. An indirect photographic method of evaluating these can, however, be obtained from consideration of the effect of soluble bromides. A slight excess of potassium bromide in developer has the effect of greatly delaying the appearance of the image and changes the course of development. The accompanying two figures (Figs. 3 and 4) show the general course of development, as measured by the growth of density at different exposures with time of development, in an unbromided and bromide developer, respectively. It will be seen that at the same time of development the curves are approximately parallel and the density is depressed by a uniform amount. This effect was used by Sheppard and later more extensively by A. H.

Nietz to evaluate the photographic reduction potential. Nietz showed that the *depression of the intersection point* of the family of curves is the most reliable measure in evaluating bromide action. The theoretical basis of this depends on the theory that the concentration of bromide will determine inversely the concentration of free silver ions, owing to the reversible reaction,

$$\overset{+}{Ag} + \overset{-}{Br} \rightleftharpoons Ag\,Br,$$

but from the equation for development as a reversible reaction,

$$\overset{+}{Ag} + \overline{\overline{R}} \rightleftharpoons Ag + \overline{R},$$
(met.)

the lower the concentration of silver ions present, the greater must be the value of the quotient $[R'']/[R']$ at equilibrium necessary to produce a supersaturated silver solution. This may be otherwise expressed by saying that the higher must be the reduction potential for equivalent concentration, for the same displacement of the equilibrium point in development, this being defined by the common intersection point of the characteristic curves, which point is independent of the time of development.

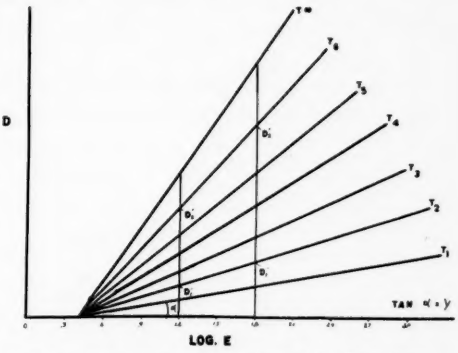


FIG. 4.—Development in Unbromided Developer.

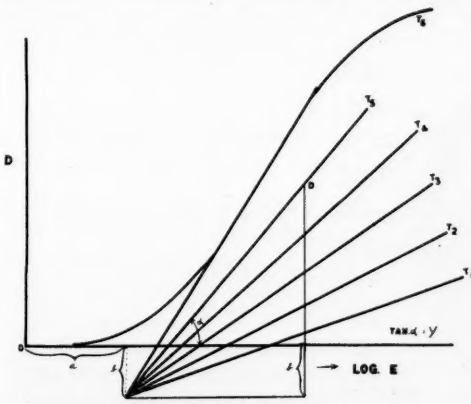


FIG. 5.—Development in Bromided Developer.

Table I by Nietz gives what are probably the most reliable results at present available for the relative reducing energies of developers.

Special Relations of Developing Power to Chemical Structure

A number of investigations have been made by the Lumières, by Andresen, and more fully by Nietz on the relation between developing power and the chemical structure of the reducing molecule, particularly in regard

to the influence of substituents. In general, it appears that the aminophenols are the most energetic, next the di- and poly-phenols and last the di- and poly-amines. While the introduction of a single methyl group in the nucleus or in an amino group increases the energy, the substitution

TABLE I

	Relative energy
$M/10$ ferrous oxalate	0.3
$M/20$ *p*-phenylene diamine, hydrochloride (no alkali)	0.3
$M/20$ *p*-phenylene diamine, hydrochloride (alkali)	0.4
$M/20$ hydroquinone	1.0 (standard)
$M/20$ *p*-phenyl glycine	1.6
$M/10$ hydroxylamine	2.0
$M/20$ toluhydroquinone	2.2
$M/20$ *p*-aminophenol (hydrochloride)	6.0
$M/20$ chlorohydroquinone	7.0
$M/20$ dimethyl *p*-aminophenol (sulfates)	10.0
$M/20$ monomethyl *p*-aminophenol (sulfates)	20.0
$M/20$ diamidophenol	30–40

of two methyl groups in an amino group appears to reduce the energy. Pronounced acid groups, such as the sulfonic and carboxyl radical substituted in the nucleus greatly lower and, if multiplied, entirely destroy the developing power. On the other hand halogen substituents in the nucleus in the case of di- and poly-phenols increase the development power.

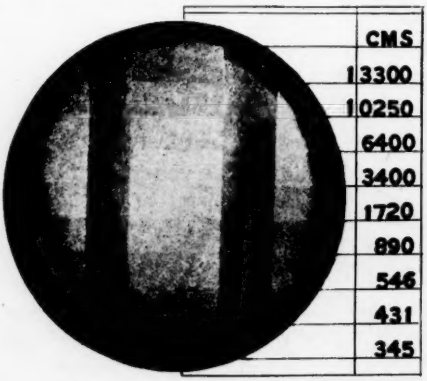


FIG. 6.—Ammonia Development.

The Solvent Effect of the Reduction Solution

It has been mentioned that besides the reduction potential another important factor controlling the properties of the developer is its solvent power upon the silver halide. Particular attention has been drawn to this, in regard to the reducing agent itself, by W. D. Bancroft. Actually in most alkaline developers, the principal solvent effect is due to the sulfite, which has considerable solvent effect on silver bromide, and much higher solvent effect on silver chloride. In consequence the development of silver chloride and bromo-chloride emulsions such as are used for developing-out paper is quite analogous to so-called physical development,

in that the process of solution of the silver halide grain is going on as fast or faster than the reduction of silver to the metallic state and its building up on the latent image nuclei. In the case of negative iodobromide emulsion, microscopical investigations show that the solution and peptization of the grain may be very considerable in developers containing high concentration of sulfite but may be very slight with developers containing little sulfite. There is, however, also a considerable difference between different reducing agents themselves in regard to this effect. Thus paraphenylene diamine is a quite powerful solvent for silver bromide, and consequently has a characteristic effect on the image. Since such solvents dissolve the silver halide in the degree that they form stable complex silver ions, the increased solution of the silver halide does not mean increased reaction velocity, a point which is frequently lost sight of.

Development with Ammonia

An interesting, although practically unimportant example of photographic development by pure solvent action is shown in the case of fuming exposed silver bromide plates with strong ammonia. The relative exposures to light must be very high to secure a differential effect between exposed and unexposed areas, but if properly carried out a very definite image can be developed. (Fig. 6.)

In this case, no reduction to silver is taking place, but the silver bromide is being dissolved (or at least disintegrated) and recrystallized as a silver bromide-ammonia complex, the "grain size" being determined by the previous exposure to light.

New Medicine Prevents Blood from Clotting. From the liver of dogs, Prof. W. H. Howell of the Johns Hopkins University has prepared an anti-coagulent, called heparin, that will keep a sample of blood in a practically normal condition for twenty-four hours.

Heparin was obtained and used by Prof. Howell in a crude form several years ago, but recent research has yielded this purified and potent form, the action of which is very much more powerful. One milligram in 100 cubic centimeters of blood will prevent the sample from clotting. Injected into the blood of persons in the same proportions, heparin will entirely prevent coagulation for about an hour. This property is gradually eliminated, however, Prof. Howell has found, in about three hours' time, when blood from such patients will clot as usual.

It is expected that heparin will be of most use in the cases where large amounts of blood, over one pint, are needed. In ten transfusion cases of secondary anemia requiring this amount, where heparin was used under Prof. Howell's direction, eight were entirely successful and only two had slight chills after the transfusion was completed.

The chemical analysis of heparin is not entirely complete but it appears to be a carbohydrate. It seems to be perfectly stable, said Prof. Howell, for specimens kept all summer in the Johns Hopkins laboratory remained unchanged and show no signs of deterioration. It has the additional advantage of being able to withstand sterilization and boiling without harm.—*Science Service*

THE STORY OF A GRAIN OF CORN. II. CORN PRODUCTS AND THEIR USES

W. R. CATHCART, CORN PRODUCTS COMPANY, NEW YORK CITY

Reference to the process flow-sheet, which appeared in the preceding article,[1] shows the following resultants from the processes described: gluten feed (cattle feed), corn oil (crude and refined), starches, dextrines and gums, corn sirup (mixed sirups, Karo), hydrol, crude corn sugar, and pure corn sugar (dextrose, cerelose). These products may be broadly divided, as to use, into food products and industrial products. In most cases, the same materials have application in both fields.

Cattle Feed

Although this subject will be allotted brief treatment, it is by no means an unimportant item in the corn products industry. From the methods described, it is evident that the various components, protein, carbohydrate, fat, etc., may be varied to meet special feeding requirements and, on account of the values represented by the complete recovery of the other portions of the corn grain, can be manufactured and sold in competition with less efficient feedstuffs. It is thus seen that the diversion of corn to manufacturing processes as carried out by the corn products industry enhances the value of this grain as cattle feed.

The present market for valuable solubles, such as Inosite and mineral salts contained in the steepwater and added to the feed, is not sufficient to warrant their separation on a commercial scale. This remains as a future prospect for the industry.

Corn Oil

Prior to the perfection of processes for refining corn oil, rendering it suitable for edible purposes, this oil was marketed solely as crude oil. As such, it is used for soap-making and, therefore, is also a source of glycerine. Other technical applications were developed, for example, sulfonated corn oil, but these have become of minor importance, until now the larger portion is refined for edible purposes. This involves the removal of the free fatty acids used for soap stock, and the elimination of objectionable odor. On account of its high "smoking" temperature, and ease of digestion, refined corn oil is preferred as a cooking oil, while the characteristic pleasant flavor and emulsifying properties make it most desirable for salad dressing, especially mayonnaise. It is now officially recognized in the category of edible oils.

Corn Starches, Dextrines, and Gums

It would indeed be difficult to decide whether the industrial or food

[1] THIS JOURNAL, 4, 547–82 (May, 1927).

uses of corn starch are more important. Should the verdict be rendered on the basis of weight consumed, it would be in favor of the industrial field.

Corn starch as food is known throughout the world. The changes which it undergoes during the processes of digestion have been thoroughly investigated. Its nutritive and calorific values are established.

The list of industries using starches, dextrines, and gums includes many of our most important manufacturing operations, such as adhesives, asbestos products, cordage, colors, explosives, foundries, laundries, oil cloth, paints, paper, rubber, textiles, etc.

How these products are used in the various processes is quite beyond the scope of this discussion. Many of these industries are responsible for the development of special forms and modifications to meet peculiar requirements.

Textile manufacturers, especially those using cotton fiber, depend upon starch to put yarn in condition for weaving. Woven and knitted fabrics are given the desired appearance and feel, that is to say "finish," by means of starches, dextrines, and gums. Manufacturers of paper, including asbestos products, likewise consume large quantities of these materials. The omission of other activities must not be considered as due to lack of importance. The field is too extensive to cover completely.

Hydrol

The name "hydrol" has been given to the sirup or mother liquor obtained from the pressed sugars and the crystallization of pure dextrose. It bears the same relation to corn sugar as molasses does to cane or beet sugar; for this reason, it is sometimes referred to as "corn sugar molasses"—a light brown sirup of approximately the following composition:

Water	20.0%
Reducing sugar (calculated as dextrose)	56.9%
Dextrine (non-reducing carbohydrates, not starch)	21.1%
Ash	2.0%

Owing to unpleasant taste, hydrol is not offered as a food product. While used for special purposes in certain industries, the fermentation industries, industrial alcohol, lactic acid, etc., are the principal consumers.

Corn Sirup—Corn Sugar

What is glucose? The chemist would probably reply—a carbohydrate having the formula $C_6H_{12}O_6$, naturally occurring in large quantities in grapes, therefore also called "grape sugar," also in numerous other fruits, vegetables, and plants, likewise designated as dextrose because of its optical activity. The chemist uses the terms "dextrose" and "glucose" synonymously and interchangeably. The medical man, physiologist or physio-

logical chemist will tell you that glucose is the sugar of the blood and tissues; the sugar into which all other carbohydrates must be transformed before utilization by the human body; the sugar which is directly assimilated without digestive change; next to alcohol, the most easily oxidized substance consumed by the human body; the principal source of muscular energy; a most valuable therapeutic agent used intravenously and otherwise. On the other hand, in commercial parlance, glucose means commercial corn sirup, which is really a mixture containing glucose or dextrose in a minor degree.

Some time ago, Dr. H. A. Hare, editor of *The Therapeutic Gazette*, asked "What would a patient receive from the druggist if the prescription called for glucose?" At that time, the U. S. Pharmacopoeia listed only "glucose," and under this listing is described corn sirup. Naturally, prescriptions calling for glucose would be filled according to the U. S. Pharmacopoeia. This, in many cases, was not what physicians had in mind or wanted. The result of this query was an article entitled, "What Is Glucose?—An Important Point in Therapeutics," published in *The Therapeutic Gazette*, August 15, 1924, in which the confusion of terms was quite fully explained.

The average composition of 43° Bé. glucose (corn sirup) is approximately:

Moisture		17.5%
Dextrose or Glucose	Calculated as reducing sugar	34.7%
Dextrine (non-reducing carbohydrates, not starch)		47.5%
Ash		0.3%

How much of the reducing sugar is maltose cannot be stated with positiveness. The probability is that some maltose is present. This is really immaterial since maltose is transformed into dextrose almost immediately in the digestive process, and must be so transformed before assimilation occurs. The dextrine is likewise converted into dextrose by the digestive process. Not prone to ferment, it is regarded as a most desirable constituent, especially in infant feeding. Thus it will be seen that commercial glucose consists of constituents which are highly important, in fact indispensable, for human nutrition. Numerous authorities of unquestioned scientific standing and integrity have given unqualified approval of the use of glucose (corn sirup) as a food.

In the *Journal of the American Medical Association*, October 18, 1919, appeared an article entitled, "Artificial Feeding of Athreptic Infants," by W. McKim Marriott, in charge of the Department of Pediatrics, Washington University Medical School and the St. Louis Children's Hospital. This was followed later, Dec. 15, 1923, by a second contribution to the same journal by Dr. Marriott and Dr. L. T. Davidson,

entitled, "Acidified Whole Milk as a Routine Infant Food." Dr. Marriott stated:

It was shown that even young or undernourished infants could, to advantage, be fed undiluted, bacterially soured, whole cow's milk, *enriched* with considerable amounts of commercial corn sirup. The tolerance for such food was found to be very high.

The following quotations are from the later article:

Such formulas were used at first only for the feeding of certain athreptic infants who failed to do well on the usual types of food. The use has gradually been extended to other infants as the advantages of this type of food became evident until, at present, approximately 90% of the infants in the St. Louis Children's Hospital are fed on lactic acid milk and corn syrup formulas.

Carbohydrate should be added to lactic acid milk, as the amount of sugar present is insufficient for the needs of the average infant. The carbohydrate of choice is commercial corn syrup, such as is obtainable in grocery stores (Karo, etc.). This syrup contains a relatively high proportion of the difficultly fermentable dextrin, and can consequently be added to the lactic acid milk feedings in large amounts without the danger of producing diarrhea.

This work of Marriott started a new epoch in infant feeding and soon medical publications contained a number of contributions by leading pediatricians of the country on the use of corn sirup for infant feeding. The conclusions reached by Dr. Randolph G. Flood of San Francisco are quoted because they are most pertinent:

In conclusion, we may state that the common sugars in infant feeding fall in two main groups, with honey occupying an intermediate position.

Group 1. Comprises those sugars which when completely hydrolyzed, give only dextrose, namely, dextrose, maltose, and Karo corn sirup. Clinically, they are noted for their ease of absorption and non-laxative action. They are ideal sugars for bottle fed babies under six months.

Group 2. Comprises lactose and cane sugar, which are slowly or not entirely absorbed in the new-born, and have a laxative action, especially sucrose, but are more readily utilized with advancing age.

Honey, a mixture of dextrose and levulose, has an intermediary position, being both readily absorbed, and a moderate laxative action.

It is striking and unusual that these authorities in their special field in recording the results of their work in medical journals of the highest standing have referred to the carbohydrate used by the trade-mark name, "Karo Corn Sirup." This is the product which had to pass through a most strenuous, acrimonious fight to get official recognition of a form of label which the consuming public could understand and which would not act as a deterrent upon consumption.

Dr. C. A. Browne, Chief of the Bureau of Chemistry, U. S. Department of Agriculture, certainly one of the leading authorities on the chemistry of sugars, in a recent address before the Association of American Dairy, Food and Drug Officials, stated:

The carbohydrate dextrose is one of the oldest food constituents in the diet of man. Its natural occurrence in the juice of all fruits and plants implies that as an article of diet dextrose, the same as levulose, sucrose and starch, is as old as the vegetarian habits of the human race. It is probably true also that dextrose as it separates out in granulated honey was the first crystalline organic substance to be noted by primitive man.

Dextrose, furthermore, occurs naturally in the blood of all animals and so far as we can determine all other digestible carbohydrates must be converted into dextrose within the animal organism before they can serve as a source of energy.

Obviously the sugar dextrose, which occurs so widely distributed in honey and in fruits and vegetables, and which has formed a part of the food of man since his first appearance upon the face of the earth, cannot be regarded as injurious, especially when we recall that most of the carbohydrates which are used as food are converted into dextrose before they can be utilized by the body.

An editorial in the *Journal of the American Medical Association*, entitled "Glucose as a Food," contains this positive and unequivocal statement:

And glucose has been decried because it is an "artificial" product—without recognition of the fact that glucose is actually derived in the alimentary tract from starch, sucrose, malt sugar and milk sugar, and furthermore that it represents the form in which carbohydrate circulates in the blood. Glucose is thus par excellence the physiologic sugar. With the use of glucose as a food preservative or dietary ingredient, the physician cannot find any fault.

That dextrose occurs, and is largely distributed in the plant and animal world, and has always been accepted since its recognition as a wholesome, necessary food, is, of course, ancient history. The early efforts to produce dextrose from these sources met with such difficulties that commercial success was not achieved. However, pure dextrose was prepared long since, but remained practically a chemical curiosity until a few years ago.

About 1811, Kirchoff discovered that from the commercial standpoint dextrose (glucose) could be produced more advantageously from starch by processes practically identical with those carried out in the human body when starch is digested and prepared for assimilation by being transformed into dextrose (glucose). Starch thus became the accepted crude material. Corn starch has been selected on account of the plentiful supply of corn, the great American cereal, and because of the high starch content of the grain. Hence the names "corn sirup" and "corn sugar."

Until a few years ago, the commercial products did not extend beyond the liquid form, corn sirup, and certain grades of solid corn sugar of comparatively lower purity. The cost of purification and crystallization of the refined product remained for a long time prohibitive for large-scale commercial production. This problem of purification and crystallization was solved economically by C. E. G. Porst and W. B. Newkirk of the Corn Products Refining Company, and pure crystallized dextrose became a commercial product. Attesting the excellency of this sugar, the Com-

mittee of Revision of the U. S. Pharmacopoeia, Tenth Edition, recommended that it be listed in the new edition which became official January 1, 1926. It is now officially listed in that publication.

The production of dextrose of such excellent quality and purity in commercial quantity was recognized as an outstanding achievement of chemical industry by the Committee on Approval of the Court of Chemical Achievement of the Chemical Exposition held in New York in 1925.

Corn sugar in the form listed in the U. S. Pharmacopoeia, Tenth Edition, is the hydrated crystal containing one molecule of water of crystallization, equivalent to about 9 per cent H_2O. The purity on dry basis is about 99.85%. This product is sold under the name "Dextrose U. S. P. X." It has been received with approval by the medical profession. Dextrose U. S. P. X is prescribed for special cases of infant and invalid feeding and has a wide application as a therapeutic agent, injected intravenously in various pathological and surgical conditions. It is the only sugar which may be introduced directly into the blood stream and become immediately available.

Without dextrose, it is doubtful if the use of insulin in the treatment of diabetes would have been successful. Diabetes is the lack of power to oxidize glucose. Insulin restores this power. If the injection of insulin reduces the glucose of the blood stream below a certain level, serious and oftentimes fatal results ensue. Dextrose, administered orally or intravenously in case of emergency, restores the equilibrium. Dextrose is used in preparatory treatment for surgical operations and as a means to meet post-operative shock, in cases of hyperemesis gravidarum, and a whole list of conditions which will not be described, as this is in no sense a medical dissertation.

The leading scientific and medical authorities fully approve the use of dextrose as a food. Processes have been perfected and factories equipped for its production. Corn growers are overloaded with corn which they would like to sell to be converted into corn sugar. The present rulings of the U. S. Department of Agriculture, however, prevent the freedom of use of this sugar as an ingredient of important and widely consumed food products.

It is important that the readers of the JOURNAL OF CHEMICAL EDUCATION should know and understand the present situation of corn sugar. The Pure Food Law of the United States is administered under a system of Standards and Definitions, many of which were formulated long before corn sugar in the pure form of dextrose became a commercial possibility. These definitions and standards are first adopted by the Joint Committee on Definitions and Standards composed of representatives of the U. S. Department of Agriculture, the Association of American Dairy, Food and Drug Officials, and the Association of Official Agricultural Chemists,

and then adopted by the Secretary of Agriculture as a guide for the officials of the Department of Agriculture in enforcing the Food and Drugs Act. It is customary for the Secretary of Agriculture to issue from time to time Food Inspection Decisions, changing or modifying definitions and standards, after such modifications have been adopted by the Joint Committee, in which committee the Department of Agriculture, especially the Bureau of Chemistry seems to be the controlling influence. Prevailing definitions appear in Circular No. 136, 1919, "Standards of Purity for Food Products —U. S. Department of Agriculture."

> Sugar is the product chemically known as sucrose (saccharose), chiefly obtained from sugar cane, sugar beets, sorghum, maple, and palm.

Some extremists have raised objection to this definition as giving sucrose a monopoly of the use of the word sugar. The definition is, of course, unscientific, but is a good practical one and insures the delivery of sucrose when sugar is asked for, which is as it should be. However, the effect of this definition is quite different when products in which sugar is used as an ingredient are defined, because whenever the word sugar is used, under the above definition only sucrose is sugar.

As stated by the official representative of the U. S. Department of Agriculture, the position of the Department is as follows:

> If there is a sweet taste there, the public ordinarily associates that taste with sucrose, ordinary sugar. That is what it ordinarily understands is used, and that is the product that ordinarily has been used by canners where they have employed sweetening agents at all in canned products.

That is to say, the consumer is supposed to believe that in candy only sucrose is present when the definition of candy permits the use of any "saccharine substance." Currant jam made only with cane sugar contains when finished 1.64% cane sugar, 52.45% reducing sugar (dextrose, levulose) out of a total sugar content of 54.09%. Honey contains 1.8% sucrose, 34.5% dextrose, 38.6% levulose. These examples could be multiplied. In short, this assumption on the part of the Department of Agriculture has no foundation in fact as far as the informed public is concerned.

Under the present rulings, jellies, jams, preserves, canned fruit, canned vegetables, ice cream, sweetened condensed milk, beverages, catsup, etc., are defined in such a way that only sucrose may be used without special label mention; that is, if sucrose were replaced in whole or in part by dextrose, this fact would have to be mentioned on the label as if calling attention to the presence of a deleterious or injurious ingredient. Canners, preservers, etc., therefore, refuse to use corn sugar, dextrose. The consuming public has been educated to believe that special label mention required by law is for the purpose of calling attention to a deleterious or injurious constituent.

In spite of this manifestly unfair discrimination by governmental authorities, corn sugar is being used extensively in certain food products. Bread is not included in the Standards and Definitions. The baking industry is the largest consumer of corn sugar, because it makes a better and more economical bread. The American Institute of Baking has issued its official Certificate of Registration for Corn Sugar.

Confectioners consume large quantities of corn sirup and corn sugar in preparing confectionery of the highest grade, primarily on account of quality, and further, because candy may be made legally with "any saccharine substance," in spite of the fact that it contains perhaps the highest percentage of "sugar" present in any food product except pure "sugar" itself.

Ice cream manufacturers are using corn sugar in increasing amounts, because they have found it produces in many respects a better and more wholesome ice cream. Many state laws authorize the use of corn sugar in ice cream and sherbets on account of its recognized value.

The Department of Agriculture very properly is most zealous and efficient in protecting the purity and wholesomeness of the food of the country. From the beginning of food regulation, the Department of Agriculture has done a wonderful work in protecting the public from harmful and deleterious products. Without exaggeration, this work has been and is one of the bulwarks of the country. Reputable manufacturers support the Pure Food Law and observe it most scrupulously, and the bigger they are, the more careful. Not one of high standing would want this law weakened or emasculated in any particular. Standards and definitions must be logical, should not be regarded as immutable and should keep pace with the progress of science and industry.

The economic importance of the corn products industry, especially corn sugar, will be discussed in the final instalment.

Tin Cans No Menace to Digestion, Scientists Say. Chemists of the Department of Agriculture are making the tin can still safer for the kitchen which counts the can opener and the frying pan as its two chief implements. That tin, the metal with which most metallic food containers are lined, has absolutely no effect on the human body is the finding of Drs. E. W. Schwartze and W. F. Clarke. Selecting asparagus and pumpkin as two kinds of preserved food which might be expected to enter into chemical union with the tin lining of the cans in which they had been preserved for long periods, these investigators were unable to demonstrate the slightest unfavorable affects of the stored vegetables when they were fed to guinea pigs. Further, they administered tin metal in two gram lots, more than all the tin on several large cans, to human beings over a period of five days. By the most refined analytical methods they could find no trace of tin in the blood stream, indicating none had been absorbed by the body.

Other experts in the same laboratory are at work determining the effect on steel cans lined with enamel instead of with a tin coating.—*Science Service*

THE TRAINING OF CEREAL CHEMISTS

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During the last twelve years cereal chemistry has emerged as a separate and well-defined sub-division from the larger division of food chemistry. That this is true is evident from the fact that a strong association of cereal chemists has been formed, in America, which supports its own journal. The factor chiefly responsible for this development was the interest manifested by the milling industry in the chemistry of flour manufacture and baking. Still more recently the merchandising of wheat on a basis of protein content has added further interest in the chemist and the chemical laboratory.

The increase in the number of chemists specializing in this field has brought with it an increased demand for three types of special training. The first involved those who desired to become routine analysts in a protein laboratory. Many second millers and others suggested that they should be afforded an opportunity to become proficient in the art of "running a Kjeldahl." They entertained the feeling that courses in chemistry which did not have to do with the nitrogen determination were valueless. To their minds, three months of concentrated application should be adequate to satisfy their requirements.

To meet such a situation in a university department of chemistry is a real problem. Most of the courses in chemistry are not organized to afford continuous laboratory exercises throughout the week. Consequently, certain industrial institutes, and trade schools undertook the training of this type of analyst. A university generally avoids the approval of a scientific training so narrow as this by granting credits, let alone a degree, to those who have no aspirations beyond the limits of one or two manipulations. It must be conceded, however, that many of the men so trained are very useful in certain industrial laboratories. They take pride in their ability to perform their tasks in an efficient manner. Be it said to their credit that some of the finest and most accurate work now being done in certain flour mills and grain-trade laboratories is performed by these analysts.

In the second group we encounter those men and women who are approaching the completion of a four- or five-year schedule or curriculum in a course leading to a bachelor of science degree in chemistry, or a chemical engineering degree. Many of these students have sensed the demand for chemists competent to organize and direct the work of a cereal laboratory. They realize that an intimate knowledge of the technology of milling or baking and the problems of industry is essential if they are to render service of immediate value. It then becomes necessary for their faculty advisor to arrange for them a rational sequence of advanced courses,

with possibly a special course in cereal chemistry if the latter is offered in the institution in question.

As a usual thing, these students have already completed the courses in general chemistry, qualitative and quantitative analysis, and organic chemistry such as are included in the sequence for a major in chemistry. To this should be added physical chemistry combined with the requisite mathematics. Early in the fourth year, a course in biochemistry should be programmed. This may parallel a laboratory schedule in food analysis which acquaints the student not only with the conventional methods of proximate analysis and the detection of adulterants, but also with the newer physico-chemical manipulations and apparatus. The polariscope, refractometer, viscometer, H-ion potentiometer, spectro-photometer, and surface-tension apparatus should become familiar tools for use in the solution of the problems of the laboratory. Policies will vary in different departments of chemistry respecting the particular courses into which such laboratory training can be fitted. This is not important, providing a competent instructor and well-selected experiments are utilized in introducing the student to these procedures.

Because of the considerable interest manifested in cereal chemistry by the students of the University of Minnesota, and the extent to which its faculty engage in research in this field, it has naturally followed that special courses for cereal chemists and technologists have been evolved here. A lecture course is offered which first acquaints the student with the laboratory methods available for use in the cereal industries; this is followed in the same course by a survey of the chemical technology of the production, marketing, grading, and milling of wheat, and the baking of flour mill products.

A parallel laboratory course affords training in experimental or small-scale milling and baking; these processes are then subjected to a biochemical and physico-chemical study. The general outline of the laboratory schedule follows:

I. Experimental milling.

   A. Mill 2000 gram portions of the wheat samples furnished by the instructor. Record weights and compute percentages of the mill products. Retain all the patent flour, and 50 grams of the bran, and of the shorts.

II. Analysis of flours and feeds produced under I.

   A. Determine the percentage of crude starch in the bran and shorts.
   B. Determine the percentage of ash in the flours.
   C. Subject the flours to experimental baking tests.

III. Analysis and testing of flour mill streams.

   A. *Chemical Analysis.* Determine the percentage of (1) moisture, (2) ash, (3) crude protein, (4) gliadin, (5) glutenin, (6) albumin and globulin, (7) non-protein nitrogen, (8) titratable acidity.

B. *Physico-chemical studies.* Determine (1) electrolytic resistant or conductivity of water extracts, (2) H-ion concentration, (3) buffer index, (4) viscosity of acidulated water suspensions (leached).

C. Technical tests. (1) Determine the percentage of wet and dry crude gluten; (2) the extensibility with the Chopin extensimeter; (3) diastatic activity; (4) changes in H-ion concentration during fermentation of the dough; (5) baking quality by means of experimental baking and expansimeter tests.

IV. Separate gliadin from a sample of flour. Determine the percentage of nitrogen in the preparation (dry basis).

V. Flour bleaching.

A. Observe the operation of the several bleaching systems at the mill. Sample the bleached and unbleached flour and record the dosage of bleaching reagent used in each instance.

B. Determine the gasoline color value and the color analysis, spectrophotometrically, of the bleached and natural flour.

C. Determine the H-ion concentration of flour before and after treatment with the bleaching reagents.

VI. Examination of cracker sponge and soda crackers.

A. Titrate the acidity in a fermented cracker sponge and compute the dosage of soda required to neutralize it.

B. Determine the H-ion concentration of baked soda crackers (1) electrometrically, (2) by the use of phenol red and cresol red, using the extraction method of Johnson and Bailey, (3) by Bohn's spot test method.

VII. Conduct baking tests with the following yeast nutrients or flour improvers; (1) calcium acid phosphate, (2) mono-ammonium phosphate, (3) ammonium persulfate, (4) ammonium chloride, (5) Arkady, in comparison with (6) a control.

Classes are large enough to permit of a detailed study of all the flour streams in typical roller mill, which study includes an observation of the behavior of these streams in the baking process. Each student works with about three flour streams of different characteristics. Data thus accumulated become available to the entire group. Five quarter credits are allowed for the completion of this extended schedule. Students are thus equipped with a fairly intimate knowledge of the fundamentals of milling and baking, and an appreciation of the problems which are likely to confront the operatives in the successful production of high quality flour and bread.

These special lecture and laboratory courses have proved attractive to agronomists and plant breeders who are concerned with the production of wheat and other cereals. Home economics students, particularly those working in the field of food technology, have also evidenced an interest in these courses.

A third group of students is interested in graduate study and research in the field of cereal chemistry. Certain of these graduate students merely desire advanced or special courses to supplement their under-graduate

work. Others wish to qualify as competent to conduct or direct research. Agricultural experiment stations, government bureaus, and many of the larger manufacturers of cereal products employ research chemists and for a time there was a scarcity of men and women capable of filling these positions.

It is true of graduate study generally that no standardized schedule of work can be devised which will suit all cases. Usually the graduate student matriculates in a particular institution because he desires to engage in research under a certain member of the staff. In the land grant colleges, it not infrequently happens that a sub-project or phase of one of the experiment station projects can be assigned to a graduate student.

Care must be exercised by the student's graduate advisor to insure that the program of graduate courses is not too narrow. Many young chemists have an inadequate familiarity with biology. A combination of courses in plant physiology, advanced organic chemistry, and biochemistry have proved well-suited to many students who can spend two or more years in graduate study.

Numerous fellowships supported by grants from industrial associations or large corporations have been provided for the support of research in these and related industrial fields. The interest thus manifested by the industries, and the financial aid afforded have done much to further the research in the particular field. Coöperation between the industries and universities is taking a more definite and tangible form in this, as in many other instances. Such an effort not only increases the volume of research activity, but has an important bearing on educational problems, since the number of research fellows can thus be increased, and better facilities for graduate study can be afforded.

Adults Learn Better than Children, Educator Finds. A man or woman under 50 years of age should seldom be discouraged from trying to learn anything which he or she really needs to learn by the fear of being too old, Dr. E. L. Thorndike, professor of educational psychology at Columbia University, declared recently at a meeting of the American Association for Adult Education. To a lesser degree, this is true after 50 years also, he added. . . . .

"Extensive experiments with adults learning algebra, science, foreign languages, and the like in evening classes, and with adults learning shorthand and typewriting in secretarial schools, support the general conclusion that ability to learn rises until about 20," he stated. "Then, perhaps after a stationary period of some years, learning ability slowly declines. The decline is very slow, however, roughly about one per cent per year."

The chief reason why adults seldom learn a new language or a new trade is not the lack of ability, but the lack of opportunity or desire, Dr. Thorndike concluded.—*Science Service*

PRIMARY CELLS—A BRIEF HISTORICAL SKETCH*

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The first consideration of an electrochemist is the source of his current. From 1800 to 1850, the scientist who was interested in the use of the electric current, was compelled to build a battery as the first step in the prosecution of his researches. Very few were so favored as the investigators at the Royal Institution of London, or l'École Polytechnique in Paris. These institutions had the largest batteries in the world, the latter donated by Napoleon.

Davy and Faraday had no dynamo for their electrochemical work. They used the large battery of two thousand plates which was in the theater of the Royal Institution in London. The care of this battery required that "every week at least a whole morning be devoted to the inspection and ordering" by the laboratory assistant, who, during Davy's régime at the Royal Institution, was Michael Faraday. Today the average student has nothing to do with an electric battery, "poor soul, electrons are fed to him from a wire, as food is to the Strassburg Geese."[1]

The primary cell is one in which chemical energy is converted into electrical energy. For this purpose it is necessary that there be two electrodes with an intermediate conducting system of such a nature that chemical reaction may take place between the electrodes and the intermediate electrolyte.

Among the notable investigators who studied the phenomena of animal electricity reported by Galvani, was an Italian philosopher, Volta, who at first accepted Galvani's thesis that the source of the electricity was the animal matter, but later, after further investigation, came to the conclusion that what Galvani had actually discovered was not the cause of the vitality of the living organism, but a new method of producing electricity. The result of Volta's investigation was the Voltaic pile, which is one of the most important discoveries in the field of electrochemistry.

The pile of Volta gave to the study of electrical phenomena a terrific impetus; an impetus even greater than that of the Leyden phial. It was, as Davy said, "the alarm-bell to experimenters in every part of Europe; and it served no less for demonstrating new properties of electricity, and for establishing the laws of this science, than as an instrument of discovery in other branches of knowledge; exhibiting relations between subjects before apparently without connection, and serving as a bond of unity between chemical and physical philosophy."[2]

* Presented by title before the joint session of the Section of History of Chemistry and Division of Chemical Education of the American Chemical Society, Philadelphia, Pa., September 9, 1926.

[1] H. E. Armstrong, *J. Soc. Chem. Ind.*, **43**, 847 (1924).

[2] "Life of Davy," by J. Davy, vol. 1, page 325.

The First Voltaic Pile

The original pile of Volta is described as follows:[3]

I provide a few dozens of small round plates or disks of copper, brass, or rather silver, an inch in diameter more or less (pieces of coin, for example), and an equal number of plates of tin, or, what is better, of zinc, nearly of the same size and figure. I make use of the term *nearly*, because great precision is not necessary, and the size in general, as well as the figure of the metallic pieces, is merely arbitrary: care only must be taken that they may be capable of being conveniently arranged one above the other, in the form of a column. I prepare also a pretty large number of circular pieces of pasteboard, or any other spongy material capable of imbibing and retaining a great deal of water or moisture, with which they must be well impregnated in order to ensure success of the experiments. These circular pieces of pasteboard, which I shall call moistened disks, I make a little smaller than the plates of metal, in order that, when interposed between them, as I shall hereafter describe, they may not project beyond them.

Having all these pieces ready in a good state, that is to say, the metallic disks very clean and dry, and the non-metallic ones well moistened with common water, or, what is much better, salt water, and slightly wiped that the moisture may not drop off, I have nothing to do but arrange them, a matter exceedingly simple and easy.

I place them horizontally, on a table or any other stand, one of the metallic pieces, for example, one of silver, and over the first I adapt one of zinc; on the second I place one of the moistened disks, then another plate of silver followed immediately by another of zinc, over which I place another of the moistened disks. In this manner I continue coupling a plate of silver with one of zinc, and always in the same order, that is to say, the silver below and the zinc above it, or *vice versa*, according as I have begun, and interpose between each of these couples a moistened disk. I continue to form, of several of these stories, a column as high as possible without any danger of its falling.

This description is followed by a discussion of the mode of operation with some of the results which he was able to obtain by the use of the current so generated. True, it was not a large current, but nevertheless it was electricity produced from a very new source.

Water Batteries

The form which Volta gave to his pile was soon abandoned. It had to be assembled every time it was used, because the plates corroded continuously when not in use. This assembling and dismounting required an inconveniently long time. Besides this, the continuity of the current depended on the use of moist cloths or pasteboard. When the pile was in continuous use for any length of time, these pieces dried out very considerably, resulting in a great diminution of the power of the system.

The pile at l'École Polytechnique in Paris, which Gay-Lussac and Thénard used in their investigations, was formed not from circular but rectangular plates, cemented one after the other into the grooves of a wooden trough, so as to leave vacant spaces or cells between them, to be filled with the liquid. Thus the pile was no longer vertical but became

[3] *Phil. Mag.*, **7**, 291 (1800).

horizontal. The plates were well cemented so that each cell was insulated from its neighbors.

The investigators of the Royal Institution of London, Davy and Faraday, used a system made in the form of a trough comprising several compartments, each containing a plate of zinc and one of copper, but they were not in metallic contact with each other. The zinc of one compartment was in contact with the copper in the next, and so on. By this means, each trough was able to contain eight or ten pairs, and the whole series of plates was fastened on a glass base so that they could be simultaneously plunged into the liquid in the trough; two thousand such pairs composed the great battery of Davy.

Various modifications of this system were built by Wollaston, Faraday, Cruickshank, Henry, Davy, Ritter, Berzelius, Hare, Pouillet, and many others before any definite departure was made from the general style and mode of "set-up."

The gigantic water battery of Gassiot[4] was very famous for its power, not only of tension but of current.

Several influences militated against the easy manipulation of even these better constructed cells. In the first place, they lost power rapidly, even for experiments which lasted only fifteen minutes, finally ceasing completely to function. This was due to the fact that the liquid which was dilute sulfuric acid attacked the zinc plates and covered them with zinc sulfate and zinc oxide, thus destroying the one great essential of the construction, namely, the homogeneity of the metallic surface of the electrodes. Hydrogen was evolved from the copper plate and covered it closely with gas bubbles that adhered with astonishing tenacity, ultimately insulating the metal from the solution. For the best results, and even for any work at all, the plates of the pile had to be cleaned every time the cell was used.

In order to avoid these inconveniences, Daniell made use of an ingenious method of separating, by means of a diaphragm, the liquids in which the respective electrodes were immersed.[5] The diaphragm was animal bladder, paper, or thin wood, or even closely woven linen cloth. The solution which surrounded the copper plates contained 8 parts of water to 1 part of sulfuric acid, and this saturated with copper sulfate; the other solution was 8 parts of water and 1 part of sulfuric acid. In some cases a little nitric acid was also added. Various forms of cell were used, the final form being cylindrical in shape.

At first, the electrodes were of sheet copper and sheet zinc, but the slow corrosion of the zinc soon led to the use of amalgamated zinc. While not in the least changing the utility of the zinc in the production of the

[4] *Phil. Trans.*, **135**, 39–52 (1844).
[5] *Ibid.*, **126**, 107 (1836).

current, the amalgam prevents its being attacked when the cell is not in actual use. This, of course, means that the electrodes need not be removed from the liquid when the cell is idle. During action, however, the zinc is attacked just as before, but the sulfate and oxide do not adhere to the electrode, thus permitting its surface to remain bright and clean. On the copper electrode, instead of an evolution of hydrogen bubbles, there is a deposition of metallic copper. This is, of course, a distinct advantage.

There is some mixing of the electrolytes through the diaphragm in the course of time; the rapidity of mixing depends upon the nature of the diaphragm material. One other effect must also be noticed. That is, in the use of the cell for an hour or two, the solutions are almost entirely exhausted and must be replaced by a fresh mixture. Not only the plates, but also the diaphragms must be thoroughly washed and carefully cleaned.

About the same time, Smee developed new ideas about the construction of a voltaic battery.[6] Smee, like Faraday, reverted from the two liquid systems to the use of a single liquid between the pairs of electrodes. One electrode was amalgamated zinc, the other was covered with finely divided platinum, *i. e.*, platinum-black; the foundation metal for the platinum-black usually was silver. These pairs were immersed in a jar or glass containing dilute sulfuric acid (1 acid to 7 water). No chemical action took place between the electrodes and the liquid until the external circuit was closed. Immediately on making contact between the electrodes, an active voltaic battery was obtained. The evolution of hydrogen gas at the cathode is so strenuous that practically no zinc is deposited in the metallic state. For long-continued use a diaphragm should separate the electrodes forming a pair.

During this period it was very difficult to obtain the smooth sheets of silver which were necessary to form smooth deposits during the platinization. One method of overcoming this was to use a copper plate; to plate this with a thin skin of copper, then with electrolytic silver, and on this last silver layer to deposit the platinum-black.

In the application of this battery it was necessary to prevent the introduction of salts of such base metals as copper or lead into the solution. If present in the solution, they were deposited at once on the cathode, thus jeopardizing the homogeneity of the platinized surface. Methods of prevention were known.

This Smee cell was a great favorite with the scientists at large, as well as with the public. It was simple to construct, readily managed, and compact in appearance. Its voltaic activity was readily started and it could be easily cleaned when not in use. True, it was not as constant as the cell of Daniell, but its capacity was not so limited.

[6] London and Edinburgh, *Phil. Mag.*, **16**, 315 (1840); *Bibl. Universal*, **27**, 186 and 386 (1840).

The most powerful cell of this period was contrived by Grove.[7] In his first cell he used two strips of gold-leaf; the one immersed in pure nitric acid, the other in hydrochloric acid. When the electrodes were connected externally so as to allow a current to flow, the piece of gold leaf in the hydrochloric acid dissolved. A test with the galvanometer indicated that the electrode in the hydrochloric acid was the same voltaically as the zinc in the ordinary pile of Volta, therefore might be replaced by zinc without interfering with the power of the cell. This was found possible. The first battery of this sort was formed from a strip of amalgamated zinc $1 \times 1^1/_4$ inch and a cylinder of platinum $^3/_4$ inch high; the bowl of a clay tobacco pipe was cemented to the bottom of an egg cup; into this was put nitric acid and the platinum cylinder; in the egg cup was put hydrochloric acid and the amalgamated zinc strip. This little voltaic combination readily decomposed acidulated water. The action was just as strong when caustic potash replaced the hydrochloric acid; but a little less when 1:4 sulfuric acid was used. This latter acid, however, exercised less local action on the zinc; hence it was preferred.

One large cell of this type was constructed by Grove containing four square feet of platinum foil; with this cell the gases, hydrogen and oxygen, could be liberated in the electrolysis of acidulated water at the rate of 110 cubic meters per minute. Another cell had fifty plates 2×4 inches, from which surprising results could be obtained: metals were melted, enormous sparks produced, and, all told the cost was about $0.25 per eight or nine hours of continuous use, as calculated at that time.

A real inconvenience of this nitric acid cell of Grove is that its constancy does not last long; if its current be allowed to flow for a few moments without interruption, provided that the conductor which connects its poles is good, nitrous vapors are seen to escape from the porous vessel in which the nitric acid is contained, and the acid itself soon becomes boiling hot. This inconvenience may be somewhat overcome by mixing a little concentrated sulfuric acid to the extent of one-half or one-third, with the nitric acid, or even taking, instead of nitric acid of a specific gravity of 1.40, some of this acid mixed with an equal volume of water. Whatever the current so loses in intensity, it gains in constancy.

The possibilities for the development of this cell were almost unlimited. Grove went so far as to believe that if electricity should ever supersede steam and become a means of locomotion, the form of the battery which he had prepared would probably be the best that could be devised.

The greatest item of expense connected with the construction of the Grove cell and the one which to some extent prevented its general use, was the electrode material—platinum foil—which, because of its extreme thinness was easily torn.

[7] Lecture to the Royal Institution, March 13, 1840.

The use of the platinum was avoided by Bunsen[8] who substituted carbon in its place. This substitution had often been attempted. Both graphite and gas-carbon had been used in the efforts, but the fact that they do not respond easily to manipulation into particular shapes and forms prevented their use on a large scale. The following is Bunsen's method of preparing his carbons. An intimate mixture is first prepared, of one part of pitcoal (by weight), and two parts of coke, in impalpable powder. This mixture is introduced into a cylindrical mould of sheet iron, in the center of which is placed a small roll of card $^1/_6$ of an inch in diameter, so as to form in the carbon an internal cavity, and facilitate the liberation of the gases during the calcination. Thus filled with the mixture of carbon, and closed by means of a movable cover, well adjusted, the iron mould is heated to redness, until all liberation of gas has ceased. After this calcination, the carbon is easily withdrawn from the mould in a compact form, cylindrical like the mould, very hard, and susceptible of submitting to the action of the file and the saw without breaking. This being done, it is well to steep, several times over, the cylinders of carbon in a concentrated solution of molasses, and to submit them to a fresh calcination as intense as possible. Many elements may be calcined together in a large earthen or iron crucible, the interstices being filled with pulverized coke. Finally, before plunging the carbon into the nitric acid, it is indispensable to cover with a film of melted wax the neck, upon which is adapted the metallic ring, or rod intended for establishing the necessary communication between the carbon and the zinc, in order to prevent the acid from coming and corroding the metal by the effect of capillarity. After each experiment, the nitric acid may remain without inconvenience in contact with the carbons. The cell containing the sulfuric acid must, on the contrary, be removed, emptied, and washed in plenty of water, as well also as the zinc cylinder.

The only precaution is that concentrated nitric is not used, but rather 1:1 acid. The current is a little less violent but it is just as constant as before; the boiling occurs after the lapse of a greater period of time because the carbon is a poorer conductor of electricity than the platinum.

Modifications of the form of the carbon electrodes were made at this time by Bonijot and Callan. The latter constructed an enormous battery, probably the largest ever made, in which cast iron was the negative element.[9] It consisted of 300 cast iron water-tight cells, each containing a porous cell and a zinc plate 4 × 4 inches; 110 cast iron cells each holding a porous cell and a zinc plate 6 × 4 inches; 177 cast iron cells, each containing a porous cell and a zinc plate 6 × 6 inches. The entire battery, therefore, consisted of 577 units containing 96 square feet of zinc and

[8] *Arch. d'Elect.*, **7**, 103 (1847).

[9] *Bibl. Universal.*, **6**, 47 (1836); **29**, 162 (1840); *Phil. Mag.*, **33**, 49 (1848).

about 200 square feet of cast iron. Each cast iron cell contained twelve parts of concentrated nitric acid with 11.5 parts of sulfuric acid; each porous cell contained a mixture of 5 parts of sulfuric acid, 2 of nitric, and 45 of water. For this were required 14 gallons of nitric and 16 of sulfuric acids.

The last of the earlier liquid primary batteries is that of Poggendorff which is known as the bichromate cell. It resembles the very first type of voltaic circle in that it contains only one liquid without a diaphragm. The solution is sulfuric acid containing some potassium bichromate or sodium bichromate, the latter being preferred. The electrodes are zinc and carbon. The zinc slowly dissolves even on standing idle; therefore, the cell is arranged so that the plate of zinc can be removed or immersed at will. The intensity is not steady, except after a long use. It serves best for high intensity over short periods of time.[10]

This cell was a development of the original Leeson cell of the same type, without the addition of the sulfuric acid.

There is practically no limit as to the combinations of metals and solutions which may be used in the construction of these voltaic piles. Two metals and an electrolyte are required. From the known metals many different cells may be built, each different from the other, yet all on the same general plan. Many curious pairs have been formed from the noble metals on the one hand, and the base metals on the other. The alkali and alkaline earth metals have been included though their intensity of action even with water renders them unsatisfactory from more than one standpoint.

Gas Batteries

The year 1843 also witnessed another development in voltaic circles which was destined to become probably more important than any of the other forms of cells. "A most extraordinary and perfectly novel voltaic battery," in which the active ingredients are gases, was described by Grove in 1843.[11] The first set-up of the new pile consisted of a series of fifty pairs of platinized-platinum plates, each about $^1/_4$ inch wide, and enclosed in tubes partially filled alternately with oxygen and hydrogen gases. The liquid in the tubes was sulfuric acid of specific gravity of 1.2.

Numerous phenomena were recorded by Grove, *e. g.*, shock, sparks, electrolytic decomposition of potassium iodide, hydrochloric acid, diluted sulfuric acid, etc., when the pile was working. When the tubes were charged with atmospheric air, no effect was observed. When the charging gases were carbon dioxide and nitrogen, or oxygen and nitrogen, no current could be detected, but when hydrogen and nitrogen were used there was a slight production of an electric current.

[10] *Pogg. Ann.*, **57,** 101 (1842).

[11] Grove, *Phil. Trans.*, **134,** 91–112 (1843); **136,** 351–61 (1845).

The origin of the voltaic current in this system was ascribed by Grove to chemical synthesis of an equal but opposite kind, in the alternate tubes. This synthesis he considered to be located at the interfaces between the phases, that is, where the liquid, gas, and metal were all in contact. The reason for the platinum-black coating on the metal was to increase the area of the points of contact, and to increase also the capillary attraction of the electrode for the liquid and the gas.

On the other hand, Schönbein[12] was of the opinion that the oxygen did not immediately contribute anything to the production of the current, but that the current was produced by the combination of the hydrogen with water to form first a suboxide of hydrogen. However, it will lead us too far afield to discuss at this point the various phases of this controversy.

Many combinations of this original gas battery were soon made. Oxygen, the oxides of nitrogen, phosphorus and sulfur, suspended in the nitrogen tube gave deflections with a galvanometer, the latter only so long as it was maintained in the fused state. Camphor, oil of turpentine, oil of cassia, alcohol, and ether were tried and all produced definite voltaic effects.

The intensity of these batteries is not so large as that of the other types, so they did not receive such general application in the large-scale investigations as did the batteries of Daniell and Grove. The development was in another direction. For the evolution of the concept of potential, a definite standard was required for comparison. In many cases the best and most satisfactory standard is a gas electrode. These electrodes or half cells, as they are called, have a constant and reproducible potential value and may be constructed without a great expenditure of time or effort. They seem to be easily handled. The hydrogen electrode of the present day has received its due amount of recognition. Its construction need not be discussed here.

One of the greatest disadvantages of the "wet cell" is the necessity of dismantling to prevent corrosion of the electrodes when the cell is not producing a current; a second factor is the splashing of the electrolyte when the cells are moved from place to place. In order to overcome these troubles, the very early philosophers made numerous investigations to determine the possibility of producing a current without the employment of a liquid. While the problem of an absolutely dry electrolyte at room temperatures was not solved, many varieties of cells, none of which were entirely valueless, were created.

Hachette and Desormes[13] replaced the liquid in the ordinary pile by starch paste. Then Behrens in 1805 prepared a dry cell from zinc, copper,

[12] *Pogg. Ann.*, **58**, 361 (1843).
[13] *Ann. chim. phys.*, **5**, 191 (1803).

and gilded paper. Some time after this de Luc in 1809 constructed a dry pile in which he used a number of alternations of two metals, with paper interposed. The particulars of the construction are simple: circular discs of thin paper are covered on one side with gold- or silver-leaf, about an inch in diameter, and similar sized pieces of thin zinc foil, so arranged that the order of succession shall be preserved throughout, namely, zinc, silver, paper, etc. An excellent pile may be made from 500 such pieces; in fact, one pile contained twenty thousand series of discs.

With the pile of de Luc as the starting point, the greatest cell of the period was developed by Zamboni in 1812.[14] The intermediate pieces of paper were coated on one side with a very thin layer of tin, and on the other side were dusted with an impalpable powder of manganese dioxide, which was fixed onto the paper by a paste of flour and milk. The moisture in the paper served in this case, just as in that of de Luc, to establish a circulation of the electricity. Because of the low conductivity of this damp paper the pile is a little slower than the "wet cells" of the same period. Decompositions and calorific phenomena were almost impossible with these piles; however, sparks could be drawn, and a Leyden jar charged by them.

The fundamental idea on which the dry piles were investigated was the voltaic theory of the pile, namely, metals in contact. It was the hope of the age that someone might be able to find a conductor for separating metallic pairs, which was not, in the first place, a liquid, yet would continually permit the generation of electricity, without being materially altered. From the standpoint of success, the results were as poor as the theory was erroneous. Piles were constructed, and they lasted for a long time, though in the end, they had a limit of endurance. On the other hand, the piles had a very limited capacity, having, as a rule, only the effect of tension, without the corresponding current. The loss in power with time was due to the fact that the paper dried out and the metals became coated with impervious oxides.

Delezenne[15] constructed a dry pile of paper tinned on one side, and covered with manganese dioxide suspended in gelatin on the other. Very large piles of 2000 to 4000 pairs decomposed water. The dioxide of manganese was gradually deoxidized while the tin was soon coated over with oxide, the net result being that after a short time the cell became totally inactive.

It was definitely known that the paper needed to be moist in order to produce any voltaic effects. In order to keep the cell from becoming inactive too rapidly when not in use, it was surrounded by dry air (dried by contact with anhydrous calcium chloride) for several hours, when it completely lost its activity. On exposing it to very humid air it at once became active again.

[14] *Ann. chim. phys.*, **11**, 190 (1812).
[15] *Arch. d'Elect.*, **5**, 67 (1845).

Another cell was constructed by Watson[16] from plates of zinc which were polished on one side. When these disks, separated by a very thin layer of moist air, were arranged with their polished faces in one direction, a tension was noticeable at the ends of the pile.

Primary Cells Containing Fused Electrolytes

The use of fused electrolytes in the preparation of primary cells dates back to Davy.[17] "As most of the fluids which act powerfully in voltaic combinations contain water, or oxygen and hydrogen, it has been suspected that these principles were essential to the effect; this, however, does not seem to be the case, for I found zinc and platinum formed powerfully electromotive circles in fused litharge and fused oxy-chlorate of potassa, which are not known to contain water; and I have little doubt that similar effects would be produced by other fused salts containing only acid and alkaline matter."

The one disadvantage of such primary cells lies in the fact that as a rule the fusion temperature is rather high, wherefore, necessarily the losses by radiation will be great, even if the amount of heat required for the initial fusion be disregarded. So far, there have been no successful cells operated on this plan. Several have been designed and described in the literature, but they are not operative on an economical scale. Two may be given particular mention: the one of Jablochkoff of 1877 and that of Jacques in 1896. Both were based on the use of one carbon electrode, and one of iron. The former cell was made active by the use of a bath of fused potassium nitrate, the latter by fused alkali hydroxides.[18]

Many different kinds of cells were studied to test the validity of the Gibbs-Helmholtz equation. Wiedemann and Negbauer[19] took into consideration the influence of temperature and the structure of the electrolyte, and also calculated the potential difference as expected according to the rule of Thomsen. Lorenz then studied intensively many cells of the Daniell type: for example $Zn \mid ZnCl_2 \mid PbCl_2 \mid Pb$.[20]

Concentration cells of the type

Ag	x_1AgNO_3 in $y_1KNO_3 + y_1NaNO_3$	x_2AgNO_3 in $y_2KNO_3 + y_2NaNO_3$	Ag

[16] *Ann. chim. phys.*, **30**, 442 (1850).

[17] Davy, *Phil. Trans.*, **116**, 406 (1826).

[18] Spread through the first volume of Faraday's "Experimental Researches" are numerous references to the use of fused electrolytes in the generation of voltaic currents. He used practically all classes of salts and found that, in most cases, fused salts worked as well as their solutions; in fact, there are only one or two exceptions.

[19] *Ann. Physik.*, **47**, 27 (1892).

[20] "Die Elektrolyse geschmolzener Salze," vol. **3**, pages 108–25.

have been investigated by Lorenz and also by Goodwin and Wentworth.[21]

Pure metals and alloys have also been used as electrodes in cells of the type

Alloy of Pb + Zn	$ZnCl_2$ + $PbCl_2$	$PbCl_2$	Pb

[21] Goodwin and Wentworth, *Phys. Rev.*, **24**, 77 (1907).

SCHEDULE OF MORNING CONFERENCES AT THE A. C. S. INSTITUTE OF CHEMISTRY

DATE	SUBJECT
July 5th (Tuesday)	Economic Factors in the Chemical Industry
July 6th (Wednesday)	Economic Factors in Industrial Research
July 7th (Thursday)	The Use of X-Ray in Research on the Structure of Non-Metallic Materials
July 8th (Friday)	Research on the Structure of Metals
July 9th (Saturday)	The Control of Corrosion—(A) Protective Coatings
July 11th (Monday)	The Control of Corrosion—(B) New Alloys
July 12th (Tuesday)	The Training of Research Chemists
July 13th (Wednesday)	The Training of Routine Plant Chemists and Continuation Education
July 14th (Thursday)	The General Theory of Catalysis
July 15th (Friday)	Ammonia Synthesis
July 16th (Saturday)	Ammonia Oxidation
July 18th (Monday)	High Pressure Synthesis
July 19th (Tuesday)	High Pressure Technique
July 20th (Wednesday)	Modern Spectrum Analysis
July 21st (Thursday)	Spectro Photometry
July 22nd (Friday)	Chemical Microscopy
July 23rd (Saturday)	New Organic Solvents
July 25th (Monday)	Determination of Particle Size
July 26th (Tuesday)	General Status and Problems of Nutrition
July 27th (Wednesday)	General Status and Problems of Nutrition
July 28th (Thursday)	Vitamins and Nutrition
July 29th (Friday)	Vitamins and Ultra-Violet Light

Successful inorganic-chemical investigations can only be carried out by such men as are not only theoretical chemists, but also perfect analysts, not only artisans with practical routine training, but thinking, plastic artists who have a deep insight into the theory of their experiments, who have stoichiometry at the tips of their fingers, who are always led by an esthetic spirit for order and cleanliness, but above all by a desire for truth.—CLEMENS WINKLER

A DEVICE FOR DEMONSTRATING BOYLE'S AND CHARLES' LAWS

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A limited inquiry has shown that the order of presentation of the principles involved in Boyle's and Charles' laws to students of chemistry and physics is very often from generalization to fact rather than from fact to generalization. This is especially true of the law of Charles dealing with the effect of temperature upon the pressure (or the volume) of an enclosed gas. It was thought that if a rapid method for the determination of the necessary data were described, more use might be made of the experimental approach to this important subject.

The effect of pressure, at constant temperature, upon the volume of an enclosed gas is easily demonstrated by a variety of simple experiments. The principles involved in Charles' law, however, are not so easily shown, neither are they so quickly grasped by the average student.

For a number of years we have made use of a single piece of apparatus for the demonstration of both of these laws. The device we have used is shown diagrammatically in Fig. 1. Although there is nothing new in principle and, even though the diagram is practically self-explanatory, still a few words of explanation may serve to indicate how easily the device may be constructed from materials found in all laboratories.

The apparatus consists of a eudiometer tube, *A*, containing a volume of air enclosed by a column of mercury contained in the rubber tube, *B*, and the mercury well, *C*. The tube, *A*, is graduated in $^1/_{10}$ cc. divisions and is conveniently made by fusing off a 25 cc. buret or Mohr's pipet at the zero mark. The tube, *A*, is enclosed in a larger tube, *D*, fitted with a two-holed stopper at the top and a three-holed stopper at the bottom. The middle hole of the lower stopper holds the eudiometer tube in the center of the jacketing tube, *D*. One of the other holes contains a tube, *E*, which admits water or the vapors of boiling liquids and the third hole is fitted with a tube and stopcock, *F* (or rubber tube with pinchcock), through which one may drain off the liquid condensed in *D*. An accurate thermometer, *G*, is held in place by the upper stopper which also carries an exit tube, *H*, attached to a condenser not shown in the diagram. *I* is a meter stick for measuring the difference in height of the balanced mercury columns. The complete apparatus is attached to a single ring-stand on which it may be kept intact and ready for use from year to year as needed. We have sometimes attached a short worm condenser and a boiling flask for generating the vapors to the same stand. This is especially convenient when the apparatus is to be carried from place to place.

It might be noted that the volume of air in the tube, *A*, should be so

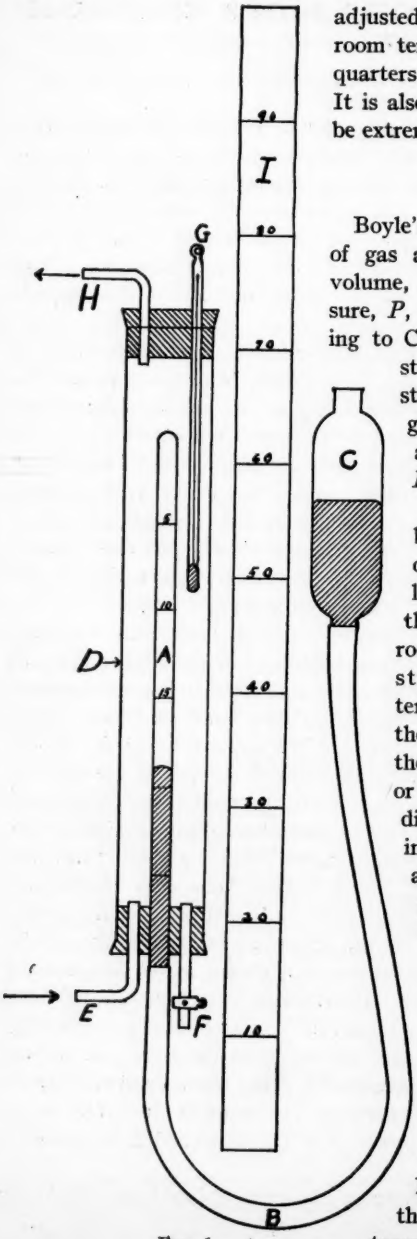

FIG. 1

adjusted that at atmospheric pressure and room temperature it will fill about three-quarters of the calibrated part of the tube. It is also very necessary that the mercury be extremely dry.

Operation

Boyle's law states that for a given mass of gas at constant temperature, T, the volume, V, varies inversely as the pressure, P, or, PV = a constant. According to Charles' law the pressure at constant volume or the volume at constant pressure of a given mass of gas is directly proportional to the absolute temperature. That is, $PV/T = K$.

We have used the apparatus both for class-room demonstration of the above laws and also for a laboratory exercise. Because of the limitation of time in the class-room we have generally demonstrated Boyle's law for a single temperature, conveniently that of the tap water. The pressure on the enclosed gas is varied by raising or lowering the mercury well. The difference in height of the mercury in the well and in the tube added algebraically to the atmospheric pressure (the total mercury column being corrected for temperature) gives the absolute pressure acting on the gas. The corresponding volumes are read directly on the graduated eudiometer. These data are tabulated on the blackboard and the constancy of the PV product shown.

For verification of Charles' law the apparatus is heated to another temperature, generally that of boil-

ing water, and the well is raised until the volume of the gas is the same as the volume occupied at zero degrees and the pressure is then read. Likewise, to determine the increase in volume at constant pressure the balanced columns of mercury are kept at the same level, the absolute pressure thus being that of the atmosphere, and the volume is then read. Since the data at zero degrees are determined with somewhat greater difficulty we have found it best to obtain these values previous to class time. All of the data are then recorded on the blackboard and the constancy of the P/T and V/T quotients shown.

As a laboratory exercise, especially for more advanced students, we have found that better results are obtained if the volumes for several pressures are measured at as many temperatures as time permits. The temperatures we have used are those obtained by a mixture of ice and water, tap-water, room-temperature, and the vapors of boiling acetone, methanol, ethyl alcohol, and water. The pressures are then plotted against the volumes for each temperature, a series of equilateral hyperbolas being obtained representing the isothermals for the gas. From these curves the pressures at constant volumes for each of the temperatures or the volumes at constant pressure may be read at as many points as desired. Likewise the mean values of the PV products, at constant temperature, may be divided by the corresponding absolute temperatures as a verification of Charles' law.

If desired the mean values of the PV products may be used to calculate the temperature of the absolute zero. To do this the variation of the PV product for one degree rise in temperature above its value at zero degree is divided into the value of the product at 0° C., or,

$$\frac{P'V' - P°V°}{t' - t°} = K. \qquad \text{and} \qquad \frac{P°V°}{K} = T, \text{ the absolute zero.}$$

The constant, K, is the specific gas constant for this mass of gas.

The following data indicate the degree of precision which may be expected with no greater refinement of technic than that indicated above. In this table the values of the PV products have been determined with a slide-rule.

Temp.	Vol. cc.	Corrected Pressure, cm. Hg	PV Const.	$\frac{PV}{T}$
0.0°	18.16	55.5	1008	
	15.82	63.6	1008	
	13.75	73.1	1007	
	11.66	86.3	1006	
		Mean	1007	3.688
15.0	18.65	57.1	1065	
	17.40	61.1	1062	

Temp.	Vol., cc.	Corrected Pressure, cm. Hg	PV Const.	$\frac{PV}{T}$
	14.35	74.1	1063	
	12.86	82.6	1062	
	11.75	90.3	1061	
	10.76	98.5	1060	
		Mean	1062	3.684
21.0	16.07	67.45	1083	
	13.14	82.5	1084	
	11.73	92.3	1083	
	10.73	100.8	1082	
		Mean	1083	3.685
56.2	16.75	73.4	1223	
	14.49	84.9	1225	
	12.88	95.4	1223	
	11.17	109.4	1222	
	9.92	123.2	1222	
		Mean	1223	3.715
77.8	19.86	66.0	1311	
	17.40	75.3	1311	
	15.06	86.85	1309	
	13.26	98.6	1308	
	12.16	107.25	1304	
	11.21	115.8	1299	
		Mean	1307	3.726
99.6	20.42	67.99	1389	
	15.45	90.00	1391	
	13.22	105.34	1393	
	11.32	122.25	1385	
	10.00	138.5	1386	
		Mean	1389	3.728
			Mean	3.704

Absolute Zero = 1007/3.7004 = 271.8°.

It will be observed that these laws may be verified with an average deviation of about two parts per thousand for Boyle's and five parts per thousand for Charles' law.

There are, of course, several sources of error for some of which correction might be made. No attempt has been made to allow for the unequal expansions of glass and mercury, nor the increased vapor pressure of mercury at the elevated temperatures. Moreover, the temperature correction of the mercury column, especially for the higher temperatures, is rather unsatisfactory due to the fact that one end of the column is much warmer than the other. However, we believe the most important source of error is that already mentioned, namely, the mercury filling the tube must be very free from volatile liquids. The variation of the vapor pressures of such liquids with temperature vitiates the results.

THE USE OF WORKING DRAWINGS IN A LABORATORY COURSE IN GENERAL CHEMISTRY

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The principal motive in the laboratory part of a course in general chemistry of today is probably that of teaching the student to do scientific investigation on an elementary scale. This is particularly true if the instructor keeps this unit of the course slightly in advance of the work of the class-room. There are some who still believe that laboratory exercises allow the student the opportunity of verifying the well-known elementary facts of chemistry for himself. Regardless of which of the two kinds of pedagogy we individually follow, we are doubtless in agreement that the student has opened for him the gates permitting the development of his powers of observation and the drawing of conclusions therefrom. All of this is done under the careful guidance afforded by the instructor and the laboratory manual.

Simultaneously the student has occasion to exercise his skill in the construction and manipulation of the appropriate apparatus for the conductance of his investigations. Herein lies one of the universally experienced difficulties in laboratory courses. Generally speaking, the manipulative part of the instruction, although brief, is sufficiently complete. Usually the apparatus is shown in scaled and lettered diagram accompanied in the paragraphed part of the instructions by a description of the correspondingly indicated parts of the diagram. In short, it is the scheme handed down from the days of alchemy and probably earlier. If the architect of today used such a cumbersome and time-killing layout of a modern chemistry building, additional foremen would be required in the construction of the plant. Instead he furnishes the contractor with a *working drawing* of the project, containing the maximum number of specifications, thereby saving paper and time in his own laboratory and time for the contractor. The likelihood of getting the desired structure is also increased.

It is now a common practice to have the students, in any of the fundamental courses in chemistry, construct a wash-bottle (or flask) as one of the first exercises. The manual contains a scaled drawing of the finished product and ample descriptive detail of the glass manipulations involved in the making of same. Quite a few teachers give the student some additional aid by putting at his disposal, for critical inspection, an actual sample. Every teacher of chemistry will readily recall that the majority of the wash-bottles presented by the class were not of a quality worthy of exhibition, although they may have served the purpose for which they were intended.

In 1922, at the University of Wisconsin, the writer was giving instruc-

tion in general chemistry to engineering students and it occurred to him that the spirit of their chosen profession might be furthered by having the bottles made to conform to specifications as given in a blue-printed working drawing. The improvement in the product was very marked.

Previous to 1923 the Division of General Chemistry of the Ohio State University supplied each student (in addition to the instructions in the manual, with a square of asbestos board ruled so as to give the angles of the two major bends in the bottle. In making the bends, the student heated the glass to the proper plasticity, placed it on the asbestos board and bent it to the angle given. When bent while in close contact with the board, the glass is less likely to sag at the bend. The ruled square has since been augmented by the scaled drawing, with dimensions, with the result that less than 15% of the wash-bottles are now returned to the students because of faulty proportions. There is also manifest the much desired uniformity in product. Figure 1 is a reproduction of the $8^1/_2'' \times 11''$ drawing furnished the student. A tolerance of 5% is usually allowed. The rulings on the asbestos board are replicas of the center lines *FF'* and *GG'*.

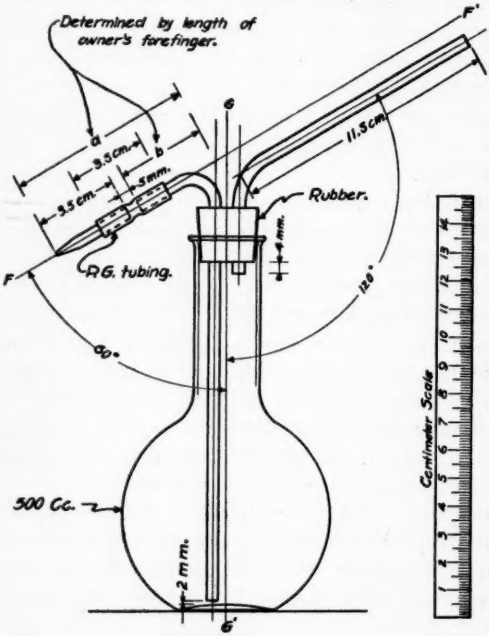

Fig. 1

The idea presented herein is rapidly being extended to the other exercises involving set-ups in the elementary chemistry courses at this university.

The all-round liberally-educated man, from Paleolithic times to the time when the earth shall become a cold cinder, will always be the same, namely, the man who follows his standards of truth and beauty, who enjoys his learning and observation, his reason, his expression, for purposes of production, that is, to add something of his own to the stock of the world's ideas.—PROF. H. F. OSBORN

Correspondence

SCIENCE TEACHING IN GREECE

Following the World War, when the Balkan States were still warm from the struggle, Turkey required the Greeks and Armenians living within her territory to leave for other countries. Many foreign schools were compelled to close or leave and chief among these was the well-founded and fast-growing Anatolia College of Merzifoun. This college followed the refugees to Greece and relocated in Salonica, a city of growing importance upon the Aegean Sea. Like all of the refugees this college left behind in Turkey much that is required for maintenance. All that Dr. White, the President, could bring with him was the hope for a new and better school.

For two and a half years the college has been growing and now faces a future of prosperity. Last year I left America to join the college staff with the desire to establish a department of sciences. In its former home the college had a well-defined course of science, but in its new home such was not the case. Last year we had no laboratories whatsoever, but this year we have a biology laboratory and a physics laboratory. Next year we shall include chemistry in our course of study, which means we will build a chemistry laboratory.

When I arrived in Salonica, not being acquainted with the language or the people, I found it practically impossible to build a laboratory. This past summer, however, I started upon the project. In my attempt to supply the needs for biology and physics I encountered scores of difficulties. In the first place buying supplies from the natives was very difficult. The custom of bargaining, which may work perfectly well for the purchase of cloth or beads does not work so well for the purchase of physical apparatus. When we purchase material in America, we need only select our material by number or name from a catalogue, mail our order and within a short time we have just what we ordered—chemicals, in well-labeled packages. Such is not the case in Greece. The merchant usually does not have what you want to begin with and tries to sell you something else. For example, I wished a small bottle of mercury bichloride. I went to a wholesale pharmacy supply house, one of the largest in the city and placed my order. The clerk promptly sought my chemical, and after half an hour appeared from the depths of his store with a dusty bottle of what he called "sublimatum." The bottle contained a label in French stating that the contents were "calomel." When I refused the material the clerk replied with the characteristic answer, "Why?" When I insisted

it was not bichloride, he frantically delivered an essay or Greek declamation probably passed down from Demosthenes, upon the fact that sublimatum and calomel were the same.

This difficulty in purchasing supplies nearly gives one gray hairs, especially when one thinks of the dangers arising in the compounding of prescriptions for medicines. I had occasion to take treatment for malaria. Included in this treatment, the prescription called for a daily dose of arsenate of iron and mercury, a formula made up by a local druggist. Upon investigating I found that his methods of compounding were accurate enough but he took such precautions as to leave his stock bottles of arsenic uncovered, because he had at some time broken the stopper, and the result was that his arsenic compound was fast oxidizing. I stopped the treatment right away and fortunately the malaria cleared up.

In an attempt to discover blue-print paper, I was finally forced to make some. I tried to purchase potassium ferricyanide, and at every attempt I received potassium ferrocyanide. After giving up the idea of using blue-print paper, I finally found a store which boasted of selling the material. Because of the fact that in early days somebody spread sand upon paper, wrote upon it and later reproduced the writing, blue-print paper is technically known as "sand writing paper."

I have been constructing a weather bureau with the hope of obtaining data which will give some light upon approaching rain or wind storms as quite frequently Salonica is subjected to strenuous wind storms of three days' duration, known as Vardars because they sweep along the Vardar River valley. I searched the city from one end to the other and nowhere could I find a mercurial barometer. Aneroid barometers are to be had in any number but no two of them agree with each other. I tried to make a barometer and in the whole city of Salonica (and Salonica has a population of over 500,000) I could not find a single piece of glass tubing suitable for making a barometer. The only tubing available was a piece of soft glass tubing which, when heated to the melting point, became porous due to the formation of minute bubbles of gas. In a marine store I found several pieces of steam boiler water-gauge tubing.

The inadequacy of supplies and the willingness to sell one thing for another are not the only setbacks one faces in establishing science courses. Governmental laws, high duties, and illogical ideas are others.

Greece is awakening to the realization of modernism and she is trying to use modern methods. Her former, out-of-date methods are so embedded into her life that modernism is finding it very difficult to gather headway.

Salonica is growing rapidly and old, poorly, constructed buildings and streets are giving away to newer ones. Within the past two years thousands of large buildings have been erected, and curious is the resultant of

forces arising from the working together of ancient and modern methods. Greece needs more of science and less of politics, yet the teaching of the former is very difficult. The situation is not hopeless by any means but it will take many years of careful training on the part of American educators in the Near East. The Greek Orthodox Church has many teachings which keep her adherents slightly aloof from ideas such as science gives, but this angle of the situation is not the most inaccessible.

The climatic and geographic conditions in Greece have kept her behind other countries in accepting modern ideas and methods. If we can train, for a few generations, the youth of Greece, he will be able to conduct the affairs of his nation quite well. The present legislators are a little slow in realizing certain of the needs of their country but as soon as they do, Greece will quickly regain her former prominent position among nations.

It is the purpose of our college to instill in our 200 boys, the idea of thinking for themselves and through the branches of study that come under the science department, I hope to stress this point with greater force than can be done through other courses. With the thoughts of adding chemistry to the course of study I am elated in that it will make our school the foremost of technical and liberal arts schools in the city. I feel confident in launching upon this new project and I am deeply indebted to many of the contributors to THIS JOURNAL for interesting and valuable articles on such subjects as relate to the teaching of chemistry.

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EQUATIONS REPRESENTING OXIDATION-REDUCTION REACTIONS

In a previous paper[1] the writer discussed the method in use in this University, in the courses in general chemistry, for the application of the electron concept to a consideration of valence and of oxidation-reduction phenomena. The method described in the above-mentioned paper has been slightly modified to meet the difficulty which the student encounters in balancing the equations for those reactions in which the same substance serves the double function of oxidizing agent and source of anions, or of reducing agent and source of anions.

In deriving the equation for the reaction of cupric sulfide with nitric acid, it is noted that the oxidation-reduction ratio is 3CuS for $2HNO_3$. The tendency of the average student is, without further reflection, to fill in these numbers in the skeleton equation. When he then tries to complete the balancing of the equation by inspection, he finds that he has

[1] THIS JOURNAL, **2**, 576–84 (July, 1925).

to change the number of molecules of nitric acid from 2 to 8 in order to account for the $6NO_3^-$ required for the $3Cu^{++}$. Making this change in the number of the molecules of the oxidizing agent tends to destroy his confidence in the method, because he is inclined to think that it is legitimate to make such changes in all equations for oxidation-reduction reactions, and he does not see that contribution is made to the work by deriving the proper electronic ratio. The better students do not run into this difficulty; but the average student, early in his work, fails to distinguish between substances which serve a double function and those which serve as the oxidizing agent or reducing agent only.

By the use of the electron change ratio to establish the numbers of the molecules of the *products* of such reactions, instead of the ratio of the molecules of the *initial substances*, the above-mentioned difficulty is avoided. In the case of the reaction of cupric sulfide with nitric acid, the steps involved in representing the number of electrons gained and lost may be written in the manner previously described.

$$\left.\begin{array}{l} HNO_3 + CuS \longrightarrow NO + S + Cu(NO_3)_2 + H_2O. \\ HNO_3 \longrightarrow NO;\ N^{5+} \longrightarrow N^{2+};\ \text{Gain } 3\ (-);\ \times 2 \\ CuS \longrightarrow S;\ S^{2-} \longrightarrow S^0;\ \text{Loss } 2\ (-);\ \times 3 \end{array}\right\} > 6\ (-).$$

Equalizing the electron changes shows that the ratio of the oxidation-reduction *products* is $2NO \equiv 3S$; and these numbers are entered in the above equation so that it becomes,

$$HNO_3 + CuS \longrightarrow 2NO + 3S + Cu(NO_3)_2 + H_2O.$$

Since no other valence changes occur under the above conditions, the final equation is obtained by completing the balancing through inspection, leaving until last the substance which serves the double function—in this case HNO_3. Since there are 3S, there must be 3CuS and $3Cu(NO_3)_2$. There are now represented 8 atoms of nitrogen in the products of the reaction and hence $8HNO_3$ must be represented. This calls for $4H_2O$ and the final equation becomes,

$$3CuS + 8HNO_3 \longrightarrow 2NO + 3S + 3Cu(NO_3)_2 + 4H_2O.$$

It is obvious that it is not necessary to write the equation in this partial form three different times; but that the proper coefficients may be entered in the original skeleton equation as soon as they are determined. The student must remember that the numbers of the molecules established by a consideration of the electronic changes are fixed points in the equation and are not to be changed in the inspection balancing; but that the other coefficients must be such as to accord with these fixed points. In the beginning of the work, this fact may be emphasized by placing a check mark over the numbers of the molecules of the oxidation-reduction products determined from a consideration of the numbers of electrons gained and lost.

As an additional example showing the completed derivation, the reaction of potassium permanganate with hydrochloric acid may be considered.

$$KMnO_4 + HCl \longrightarrow MnCl_2 + KCl + Cl_2 + H_2O.$$
$$KMnO_4 \longrightarrow MnCl_2;\ Mn^{7+} \longrightarrow Mn^{2+};\ \text{Gain } 5\ (-);\ \times 2$$
$$2HCl \longrightarrow Cl_2;\quad 2Cl^{1-} \longrightarrow Cl_2^0;\ \text{Loss } 2\ (-);\ \times 5 \Big\} > 10\ (-).$$
$$2KMnO_4 + 16HCl \longrightarrow 2MnCl_2 + 2KCl + 5Cl_2 + 8H_2O.$$

It should be noted that the method with this modification is equally applicable to those cases in which a given substance serves as oxidizing agent or reducing agent only, and to those in which the same substance serves the double function illustrated.

Methods, differing to a greater or lesser degree from that described above, have been discussed by Waldbauer and Thrun,[2] and by Lochte.[3] In the light of modern concepts, all of these schemes are better than the methods based on "nascent oxygen" and "key reactions." It is the writer's experience that this modification of the method previously described by him furnishes the student the simplest method of attack in the derivations of equations to represent oxidation-reduction phenomena.

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TO THE EDITOR:

I would like to ask you to publish a warning against the use of the experiment on silvering a mirror. This experiment is printed in a good many high-school laboratory manuals with no warning of danger. The experiment came to my attention through a girl who wished to demonstrate it to the class—she knew how because her father did it at home. I accepted it without question and the experiment became popular.

Two weeks ago a student prepared the usual solution of silver nitrate, ammonium hydroxide, and Rochelle salts and, as we have only single laboratory periods, had to set it aside for a week. When he took out the little beaker with its watch glass over it and put in a glass rod to stir the solution it exploded violently into his face and eyes. We have been very anxious about his sight for a week but he is now safe. I have spoken to a number of chemistry teachers and find that they too are using this experiment, unconscious of the danger.

Will you please have some one write a warning and publish it in your journal because we have enough safe experiments? I do not want any

[2] THIS JOURNAL, **3**, 1430–1 (Dec., 1926).
[3] *Ibid.*, **4**, 223–7 (Feb., 1927).

other teacher to go through the mental torture I have been through this week.

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EDITOR'S NOTE: The accident here described was probably due to the formation of silver fulminate and should not occur unless the solution used has been allowed to stand for some time.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces an open competitive examination for Senior Chemist.

Applications for senior chemist must be on file with the Civil-Service Commission at Washington, D. C., not later than July 12th.

The examination is to fill vacancies in the Fixed Nitrogen Research Laboratory, Department of Agriculture, Washington, D. C., and in positions requiring similar qualifications.

The entrance salary is $5200 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions.

The duties will be to plan and supervise the research work of a group of physical chemists, organic chemists, and biochemists on the mechanism of the chemical reactions involved in nitrogen fixation and the application of this knowledge to practical procedures for the manufacture of compounds suitable for use in agriculture.

Competitors will be rated on their education and experience, and writings to be filed with the application.

Full information may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post-office or customhouse in any city.

I value in a scientific mind, most of all, that love of truth, that care in its pursuit, and that humility of mind which makes the possibility of error always present more than any other quality. This is the mind which has built up modern science to its present perfection, which has laid one stone upon the other with such care that it today offers to the world the most complete monument to human reason. This is the mind which is destined to govern the world in the future, and to solve the problems pertaining to politics and humanity as well as to inanimate nature. It is the only mind which appreciates the imperfections of the human reason, and is thus careful to guard against them. It is the only mind that values the truth as it should be valued and ignores all personal feeling in its pursuit.—PROF. H. A. ROWLAND

Chemical Digest

ABSTRACTS

Making the World Safe for Science. DEF. WIDGER. *Trans. Ill. State Acad. Sci.*, **19,** 389–98 (1926).—A comparison of certain features in the myth of Prometheus in contrast to those found in the recent story of Frankenstein leads the author to ask, "Is modern science to be Prometheus or Frankenstein in our civilization, the instrument of this world's salvation or the diabolical instrument of its destruction?" The advances in knowledge made by scientific men are pictured by Haldane, and by Wells, as Prometheus who bestows upon mankind the fire of heaven; but, with Bertrand Russell, the author questions whether it may not turn out that, like Frankenstein, we have created in science a monster that will kill the very things we cherish. He asks whether science has given us more self-control, more kindliness, more power of discounting our passions. He argues that during the great war, although science gave the means of saving life and relieving pain, it also gave the deadly gases and liquid fire and the means of destruction of priceless treasures of art.

It is urged that the world be made safe for science, first by extending the scientific method of thinking; and, second, by making a greater use of art in changing the quality of men's desires, emotions, and passions.

The spirit of the scientist is the spirit of the humble learner laboring without prejudice or rancor. It is passing strange that so shining an example has produced so little effect upon the great mass of thinking, and that while living in the twentieth century the mode of thinking is so much that of the Dark Ages. The first business of education is to emancipate the mind from narrowness and prejudice. Education must attempt to change the mass of emotion by means of art, music, religion, sculpture, architecture, and literature.

The author concludes that if men use science as a means of extending power over nature, but refuse at the same time to use art as a means of extending control over human passions, it may turn out that, like Frankenstein's creature, science may become a curse. But it need not be so, since there is no conflict between science and art; rather, they complement and supplement each other. Through art we can make men love truth rather than prejudice, light rather than darkness, and thus proclaim the reign of Prometheus, and make the world safe for science. R. M. P.

The Training of Teachers of General Science. SAMUEL S. VERNON. *Trans. Ill. State Acad. Sci.*, **19,** 419–25 (1926).—Within very recent times a few normal schools and universities are offering courses adapted to the training of teachers of general science but in a large number of teacher-training institutions no such course is offered. The poorly trained teacher of general science is most liable to commit the greatest offences in the field of science teaching. Boys and girls in the high schools are reading scientific magazines and are sophisticated enough to know when the teacher is bluffing. The teacher must be alive and keep informed of the new truths in science.

The author recommends as specific academic subjects for the training of teachers of general science the following college courses: Two years of chemistry, including general chemistry, qualitative analysis, and organic chemistry; and one year each of physics, zoölogy, botany, and geology.

The professional training of a teacher of general science should place special emphasis on courses dealing with science instruction including the problem of laboratory technic. The function of the teachers of general science is to bring the boys and girls into contact with the truths of the vast field of science and to act as interpreters of these facts. R. M. P.

The Need of a National Code of Ethics for Teachers. W. G. REEDER. *Sch. and Soc.*, **25,** 417–21 (April 9, 1927).—An address before the Educational Section of the American Association for the Advancement of Science, in which is discussed the need and value of codes of ethics. In every group there are those who, either intentionally or unintentionally, violate accepted standards of conduct and who fail to recognize right from wrong. Most professions have, within recent years, adopted codes of ethics but the teaching profession has been slow in recognizing the value of such codes.

Though many of the teacher's associations have codes, a national code, such as other professions employ, is lacking. A code of this character would not only serve as a guide for the ignorant and deter those who do wrong, despite the fact that they know right from wrong, but would dignify the profession by having the endorsement of almost one million teachers. K. S. H.

What's Wrong with the American High School? FRANCES M. SMITH. *Sch. and Soc.*, **25,** 459–61 (April 16, 1927).—For the past twenty years, American educators have endeavored to present an elaborate and marvelous educational setting in an effort to introduce real education into the American high school. Unfortunately, the tremendous growth which the high schools have experienced has not been accompanied by a careful choice of teaching staffs. Too few of those whom we call teachers possess either the instinct or training necessary for successful teaching.

"Isn't it time," the author asks, "that the taxpayer have some knowledge as to what the annual expenditure of half a billion dollars on education is accomplishing?" K. S. H.

New Uses for Salt. J. WYNN. *Am. Mercury*, **10,** 445–8 (April, 1927).—The effect of sodium chloride on intracranial tension and its new and important use in brain surgery are fully discussed in this article. The author also discusses another valuable therapeutic use which recent investigations have revealed, namely, its use in combating the toxemia resulting from bowel obstruction. Cases are cited where recovery has been both complete and satisfactory. K. S. H.

Early Emotions and Early Reactions as Related to Mature Character. C. H. JUDD. *Sch. and Soc.*, **25,** 355–60 (Mar. 26, 1927).—The author explains the importance of early impressions in conditioning future actions. The school and pre-school years are important periods, as well as later periods of school life, where attitudes are obtained which serve to adjust the individual to his social environment. K. S. H.

A Critique of the Present Status of Curriculum-Making. H. HARAP. *Sch. and Soc.*, **25,** 207–16 (Feb. 19, 1926).—The important steps in the process of curriculum-making are outlined and many of the limitations in the ways in which these steps are being carried out are stressed. Several methods of determining the objectives of education are considered, their advantages and limitations being set forth. One of the greatest deficiencies in present curriculum-making is failure to comprehend the nature of school activity. K. S. H.

The Chemical Story of Local Anesthetics. A. J. HILL. *Rept. New England Assoc. Chem. Teachers*, **28,** 115 (March, 1927).—Local anesthesia was practiced as early as 2500 B. C. by pressure to nerve trunks and arteries by which the hands and feet were caused to fall asleep. Paralysis and gangrene occasionally resulted from its practice. Extractions of plants containing opium and atropine were used in the first century. The use of cold was first effected by blowing carbon dioxide upon wounds, and by the application of ice and salt. In 1867 the ether spray was developed and more recently ethyl chloride.

The aborigines of Peru were aware of the properties of the juice of cocoa leaves and used it to alleviate pain. In 1858 cocaine was extracted from cocoa leaves, but its uses were not appreciated until 1884. Later its study led to the development of novocaine or procaine, which is only one-seventh as toxic as cocaine and as efficient in most cases. The success of novocaine led to many attempts to synthesize compounds of similar type.

Recently butyn, tuocaine, and psicaine have been synthesized and are finding important applications. Experience has shown that amino esters and aromatic alcohols are local anesthetics, and that in amino esters a three carbon chain is usually better than a two carbon chain and always better than the four or five carbon chains; acidic groups depress physiological activity. The hydrogen-ion concentration of local anesthetic solutions is very important. As early as 1888 it was noted that in certain cases the activity increased with a decrease in acidity, but it was almost unnoticed until 1910. This has led to the substitution of the compounds for the hydrochlorides. The chief factors which bring about defeat in the synthesis of a good anesthetic are: toxicity, lack of solubility, irritability to tissue, and the misbehavior of the introduced groups. The body chemistry, or the mechanism of local anesthetic action, is still largely speculation. D. C. L.

Kekulé and His Hexagon. HARRY LEFFERMANN. *Bull. Wagner Free Inst. Sci.*, **1,** 51 (Feb., 1927).—This contains a brief account of the work of Kekulé and his ideas in regard to the structure of benzene. Benzene was first prepared in 1825, while Kekulé's paper on "The Constitution of Aromatic Substances" was read in Paris in 1865. In the published paper in 1866 he proposed the hexagon practically as used today, with

the alternate values of one and two. The hexagon as proposed was a regular figure, although many chemists have fallen into the habit of lengthening the two sides. D. C. L.

Environmental Chemistry in the Class-Room. C. H. STONE. *Rept. New England Assoc. Chem. Teachers*, **28,** 108 (March, 1927).—By means of experiments drawn from local industries and the everyday life of the student, the author enlivens his subject and interests the student. Demonstration has little teaching value unless accompanied or preceded by thought-provoking questions. Among the experiments selected were: the use of thermit in the reduction of less active metals and in welding; the preparation of copperas from iron and its use with tannic acid and gum arabic in making ink; the use of ferrous salts in blueprinting; the testing of ordinary foil for Al and Pb; cheap gold jewelry from Cu; the demonstration of the low melting point alloys used in automatic fire plugs; electroplating; the separation of silver and copper in a dime; electrolytic cleaning of silver; the preparation of lime sulfur spray and Bordeaux mixture; the preparation of Paris Green and lead acetate; testing paint for lead and water for nitrates; testing for wool in mixed goods; the dyeing of various types of cloth; and the preparation of some easily prepared dye such as Orange II. D. C. L.

The History of Glass Making—Optical Glass. JOSEPH F. HEFFRON. *Glass Container*, **6,** 10–3 (April, 1927).—This article deals briefly with the historical development of lenses dating from the use of lenses of rock crystal in Nineveh, 600 B. C., to the present day. The Greeks and Romans knew of the magnifying effects of a glass sphere filled with water. The Chinese early made use of rock crystals as visual aids, and the use of spectacles dates back at least six centuries. The spectacle makers produced the first simple microscopes and invented the telescope and the compound microscope. Numerous improvements were made until the present state of perfection was attained with a limit of visibility of 0.0001 mm., and with the ultramicroscope 0.0000002 mm. in diameter. Until the close of the 18th century optical glass was unknown, the material for lenses being selected from the best pieces of ordinary glass, so that due to imperfections, only small lenses could be made. Guinand, a Swiss watch maker, first produced optical glass by discovering that mechanical agitation removed many of the imperfections. This was also discovered independently by Michael Faraday. Much credit is due to the work of Abbe, Schott, Carl, and Zeiss in investigating the effect of various oxides.

Prior to 1888 no optical glass was produced in this country. The Macbeth-Evans Co. produced the first high-grade optical glass in this country, but due to competition with low costs in Europe and the belief that good optical glass could not be produced in the U. S., it was a commercial failure. In 1914 with the coöperation of the Bureau of Standards an optical glass industry was developed which produces a large portion of the optical glass used on this continent. Every instrument of precision through which light passes requires optical glass which differs from ordinary glass almost as much as does the diamond from graphite. Optical glass is difficult to manufacture. It calls for carefully selected ingredients, exact temperature control, thorough agitation to secure homogeneity, and slow cooling. It must be free from bubbles and strains. Because of the many rigorous requirements, the average yield of good optical glass in a successful melt rarely exceeds 20 per cent of the total melt. D. C. L.

Liquid Chlorine—Its Manufacture and Use. D. A. PRITCHARD AND J. H. HUBEL. *Can. Chem. Met.*, **11,** 81 (April, 1927).—The brine from the wells is treated with the calculated amount of Na_2CO_3 to remove lime salts, and the hot brine is then electrolyzed in the Gibbs cell. The liberated chlorine gas is dried by passage through forty foot towers with a counter current of H_2SO_4, thus making possible liquefaction in iron equipment. 50 per cent of the liquid chlorine manufactured in the U. S. and Canada is consumed in the pulp and paper industry, 15 per cent in the textile industry, 16 per cent in sanitation, and 19 per cent in all other uses. Bleaching of wood, pulp, or textiles may be accomplished with either calcium or sodium hypochlorite; the latter is preferable, due to its greater solubility and consequent ease of removal by washing. The bleach is made by adding the calculated amount of liquid chlorine to NaOH solution, doing away with the troublesome handling of chloride of lime.

Bleaching powder was first used in America to sterilize drinking water in 1908. With its use, there was a large drop in deaths from typhoid fever. Properly chlorinated water contains about 0.2 part per million and costs one cent per person per year. One part chlorine in 133,000 has a curative value in colds and similar diseases. Chlorine finds important applications in metallurgy and the preparation of metallic chlorides. With tin and aluminum it must be dry, while with iron and zinc it must be in the presence of water. It is used in the petroleum industry to remove mercaptans, and in the manufacture of ethylene dichloride, an important solvent, and ethylene glycol used in

anti-freeze mixtures. In organic chemistry it is used to form addition, substitution, and oxidation products, and in combination with other elements such as $AlCl_3$ and SCl_2 to produce anhydrides and effect condensation. Of 44 different substances used in gas warfare at the end of the war, 31 contain chlorine. D. C. L.

Manufacture of Yeast and Its Products. A. LINTON DAVIDSON. *Can. Chem. Met.*, **11,** 90 (April, 1927).—This article treats of the production of chemical, medicinal, and food products from yeast. At the end of the last century the English brewers were glad to sell their surplus brewery yeast for 60 cents a ton delivered, but in 1916 it sold for $29.00 a ton. Yeast was first prescribed in the diet by Hippocrates in the fifth century B. C., being used in the treatment of leucorrhoea. Owing to its contamination with pathogenic organisms it gradually fell into desuetude, but was again brought to light in 1830 as a cure for scurvy. The consumption in the U. S. rose from 35 lbs. per capita in 1890 to 100 lbs. in 1910.

The chief chemical products prepared from yeast are nucleic acid and thyminic acid. The yield of nucleic acid is about 0.5 per cent of the pressed yeast used. Sodium nucleate is used in cases of intestinal perforation and tubercular abscesses, and to increase the resistance of the body in major surgical operations. Cases of syphilis have completely recovered as a result of sodium nucleate injections without having recourse to mercurial treatment. Nucleic acid is valuable in treatments for progressive paralysis, paralytic dementia, scarletina, and erysipelas. Solurol, impure thyminic acid, has the property of dissolving and keeping in solution the uric acid in the blood, tissues, and joints of a gouty subject. Thyminic acid can hold in solution at body temperature its own weight of uric acid. The yeast residues after hydrolysis to remove nucleic and thyminic acid are used as cattle feed selling for about $40.00 per ton. No plant can produce the mineral salts and proteins needed by the body as economically as the yeast plant. In 13 hours it produces a yield of 7400 per cent. In one city block, with 25 workmen there could be produced 10,000 to 15,000 tons of yeast per year—more food than can be grown on 75,000 acres employing 1000 workmen. D. C. L.

The Stimulation of Research in Pure Science Which Has Resulted from the Needs of Engineers and of Industry. W. R. WHITNEY. *Science*, **65,** 287–9 (Mar. 25, 1927).—The beginnings of research may well go as far back as the experimental motions of the first amoeba-like creature. We are still nearer the amoeba stage than that of complete appreciation.

Since Francis Bacon's time research has become organized and of late is quite as extensive in industries as in the university as measured by publication of valuable papers. University research is still largely pioneer in nature while industrial research is developmental. Artificial distinctions as to kind or source of research are invidious, but for purposes of discussion Ball's eight classes of research are accepted. The engineer is interested in types *b* to *d*, mainly concerned in collecting new or more accurate data. These types if ill used may kill curiosity. The engineer uses the information collected by the "*a*" type of research (pure research). "Strangely enough, it has always resulted that the most remote observations, the most unusual experiments, the most unexpected phenomena, the most insignificant new facts and the most unnecessary discoveries developed into subsequent needs and necessities, but the needs have not usually pointed ahead toward new discoveries. It is becoming more and more clear that the limits of advancement of man are in his own head and hands, and only realized through a process of appreciating nature." G. H. W.

Research in Colleges and Professional Schools. MAYNARD METCALF. *Science*, **65,** 307–8 (April 1, 1927).—Contrary to the view held by some college and university professors that qualified research men are rare and that most teachers would do well to let research alone, the writer believes that everyone has something of the spirit of research and that the best teachers are those who have this spirit and are capable of imparting it to others.

This is the first of a series of papers arranged by the secretary of the committee on research in educational institutions. The second paper, "Research in Medical Schools," by Dr. Florence R. Sabin, follows. G. H. W.

Agriculture and Modern Science. W. M. JARDINE. *Science*, **65,** 333–8 (April 8, 1927).—An excellent summary of the relation of chemistry, physics, biology, meteorology, and economics to recent developments in agriculture. G. H. W.

Research in Colleges and Professional Schools. II. MAYNARD M. METCALF. *Science*, **65,** 338–42 (April 8, 1927).—An elaborate report and analysis of conditions designed to prevent the distressingly high "research death rate" among college and university teachers. Conspicuous examples of colleges with strong research histories are cited as evidence that the situation is not hopeless. G. H. W.

Research Experience and Problems in a Small College. H. B. GOODRICH. *Science*, **65**, 342–5 (April 8, 1927).—An analysis of research production at Connecticut Wesleyan University. Research began there with the coming of Wilbur O. Atwater in 1873. Curves are given covering the period 1830–1926 showing number of faculty, number of students, number of graduate students, and number of faculty publishing original papers. The number of faculty publishing papers is much more evidently related to the number of graduate students than to the faculty-student ratio. G. H. W.

The Degree of Doctor of Philosophy. E. C. HILLS. *Bull. Am. Assoc. Univ. Profs.*, **13**, 163–85 (Mar., 1927).—This study summarizes the returns from a questionnaire and represents practices and comments from administrators in sixteen leading universities.

The study includes attention to such items as; the minor, where it may be taken, work required upon it, who determines what it shall be; the examination for the doctor's degree, by whom given, its character, whether written or oral or both, the use of a preliminary examination, type of questions used; the dissertation, its relation to the examinations, and its publication.

One question implied the use of library tools of investigation as a part of the test of the candidate's fitness for the degree. Very few institutions include that as a part of the examination though a number of administrators were impressed with its promise for such use.

In connection with minors, 50 per cent of schools reporting require no minor; if the candidate takes a minor most schools (70 per cent) definitely prescribe how much work shall be done on it. The examining committee almost universally contains members from more than one department; both a preliminary and a final examination are given by 80 per cent of schools, and these are both oral and written in 70 per cent of schools reporting. The dissertation must be accepted by the committee before the final is given in 80 per cent of the schools. Only about 45 per cent of the schools require that the candidate bind and publish his thesis himself. "The drift seems to be away from this requirement (the printing of the dissertation)." Fully 50 per cent of the article is given to constructive suggestions quoted from letters included with the returned questionnaires. B. C. H.

Chemistry and the Institute of Politics. FRANK C. WHITMORE. *Chem. Bull.*, **14**, 35 (Feb., 1927).—After outlining the origin, purpose, and program of the institute, Doctor Whitmore speaks of the place and contribution of chemistry to the program. The year 1926 was the first to find chemistry included in the Institute's offerings. Two foreign speakers of interest to chemists were James C. Irvine and Umberto Pomilio. The latter discussed Italy's geothermal power and electrochemical industries.

The part of chemistry in the Institute's program included: a daily round-table; a general conference of all members of the Institute upon "The Rôle of Chemistry in the World's Future Affairs" held once a week and a short course intended to give the members of the Institute a better idea of what chemistry really is.

Doctor Whitmore considers that the part of chemistry in the program taught the non-chemist members that the world is changing very rapidly; that things which have always caused war may not always be such causes; that materials which have been of great value may not always be of such importance, that substitutes for them may be found; that industry does not need a certain material but rather certain definite properties which might conceivably be found in some other material. He reports that the Institute did much to sell chemistry to the public, but he was impressed that it is high time that the public be given the "true idea of chemistry and not have them think it is a science of magic. . . We (should) let the public know not only what we can do but how we do it." B. C. H.

Use of Ethylene in the Chemical Ripening of Fruits and Vegetables. R. B. HARVEY. *Chem. Bull.*, **14**, 101 (April, 1927).—Three years ago the author discovered that ethylene and propylene speeded up the ripening processes in fruits and vegetables. The first commercial application was the blanching of celery. F. E. Denny had previously found that unsaturated hydrocarbons could be used in coloration of citrus fruits. True and Sievers had found that a mixture of carbon dioxide and carbon monoxide produced more rapid coloration. The Chinese had long ripened pears in confined places by the gases from incomplete combustion of incense. The action of ethylene in removing the acidity and increasing sugar content was not known.

The author has found that celery treated with ethylene has its sugar content increased 20 to 30 per cent. Similar changes occur in bananas, rhubarb, pineapples, apples, persimmons, plums, and other fruits, as well as garden vegetables. This is a great advantage over the other gases as they produce a ripe color but leave the food

with a sour, unripe taste. Very immature fruits—tomatoes one inch in diameter—can be made marketable by ethylene. This treatment promises to lengthen the season by ripening immature fruits before the regular season, save fruit caught by frost and prevent loss due to shipment of nearly ripe fruits. Ethylene is very cheap and a very little of it mixed with the air is sufficient (1:1000) for ripening purposes. It seems to have no harmful effect on workers nor is it explosive at this small concentration. Propylene has the same effect as ethylene although it is more expensive and not so available commercially at present as is ethylene. E. L. M.

The Relation of the Senior College and the Graduate School. ERNEST H. WILKINS. *Bull. Am. Assoc. Univ. Profs.*, **13**, 107 (Feb., 1927).—Dean Wilkins traces the traditional four-year college back to the University of Paris in the thirteenth century. This he considers no adequate reason for its perpetuation. Its continuance he considers warranted only if it has a peculiar adaptability to our present needs. He does not find this adaptability, so proceeds to show reasons for not only a recognition of a division line between the second and third years of the four-year course, but strongly urges, if not the physical separation of the first two years, junior college, from the last two years, senior college, at least a separation of their administrations.

The junior college aim is considered the attainment of a general education. This should classify it with the senior high school.

Increased maturity of its students, the beginnings of concentration of effort, the general registration practice of many of the larger universities today all suggest the association of the senior college with the graduate college so far as administration is concerned.

Many arguments are advanced, setting forth advantages accruing to both groups by this type of organization. Problems of administration are considered, including types of degrees, and times of graduation. B. C. H.

Research on Nickel and Its Alloys. PAUL D. MERICA. *Inco.*, **7**, 18–20 (1927).—Metals are valuable for their properties. When the buyer purchases metals, he is, then, really "purchasing properties, performance and service; strength, wear resistance, corrosion resistance, fabricability.

"A modern user of materials often requires that a metal fulfil rather complicated and difficult requirements." This necessitates that a salesman know the properties of his product with great precision. The accumulation of such information is the function of research and testing laboratories.

The research work of the laboratories may be said to take four general directions: (1) The fabrication of metals with properties demanded by users; (2) solution of problems submitted by users of the metals; (3) the development of new nickel products; and (4) the development and improvement of processing of different products.

In carrying forward this work, special instruments of precision must often be designed, and while there may be times when test by nose or tongue may suffice, generally the requirements are those of the accuracy of engineers' measurements.

The present age might be characterized as the "specification age." "We use, today, not bronze or iron or steel, but a variety of particular materials with definite sets or combinations of properties." B. C. H.

The Junior College Movement and Its Effect on the Reorganization of Science. WALTON B. BLISS. *High-School Teacher*, **3**, 104–5 (Mar., 1927).—A discussion is given of the junior college movement in outline form including these headings:

1. The background for interpreting current practices and tendencies in this field—History of movement and survey of courses of study.
2. Types of junior colleges—Public and private, state institution, etc.
3. The Scope of Movement—Enrolment 20,000 in year 1922–23—200 institutions in three-fourths of states of U. S.
4. The meaning of the movement—Literature shows 21 "special purposes" clearly recognized as functions of the junior college.
5. The forces of reorganization in secondary education shown, for example, in the document, "Reorganization of Science in Secondary Schools" (U. S. Bureau of Education, Bulletin 1920, No. 26), indicate an upward trend of high-school education.
6. There is a marked distinction between the university and all education below that level.
7. The present forms of liberal arts college curricula incompletely meet the needs of the four-year graduates measured in terms of their occupational destinations during the early years out of college. The junior college must assist in this.
8. The strong junior college can adequately give the first two years of the curri-

cula in pre-professional and professional work, where these professional curricula begin with the first college year.

9. The controlling educational purposes of the public junior college should be to provide for a reasonably complete education, whether general or vocational.

E. L. M.

The Evils of Standardized Education. C. W. BURR. *Gen. Mag. and Hist. Chron.*, **29**, 312–23 (April, 1927).—The author discusses the primary purpose of education and names two aims: moral and intellectual training. He questions if the American public school is the best for the purpose. It offers all children the same mental food. Personality is the sum of three things—temperament, character, intellect. These are discussed at length. Since personality is the material the school works on, the author tries to roughly classify children into three groups: hand-minded; intellectual; pick and shovel type. The schools handle by one standardized system those who have only muscular ability; those fitted to run machines; those capable of intellectual work.

One thing in education must be standardized: the moral code. School education should vary according to the mental group to which a boy belongs. Our educational system tries to make the unintellectual intellectual, and of necessity fails. Most boys get out of school all they can, by the fourteenth year. The ambition of parents and families is filling our colleges with students who cannot study.

We Americans do not like to admit the existence of the pick and shovel type. It does exist and is most common. As to the hand-minded, one of the newer educational theories injures where it claims to help the mechanically minded; the author refers to vocational training. There is too much training by females in the American public school. A wise school master in a wooden shack will send forth a better product than a whole faculty of machine-made teachers, working in a palatial school, with all the mechanical hygienic improvements. In standardized education, no thought is taken of genius. The author then discusses the ideal system of public education. It assumes both mental inequality and mental differences apart from the question of equality. No boy under 10 should be taught by men; over ten his schooling should be entirely in the hands of men. The moral imbecile should have little intellectual training because he will misuse it. The really scholastically minded should have every educational advantage the state can give. "Give the best, the best that can be given."

J. H. G.

The Contribution of Science to the Welfare of the Nation. *Sci. Mo.*, **24**, 193–213 (March, 1927).—A series of papers prepared for the celebration of the 150th anniversary of the signing of the Declaration of Independence by the A. A. A. S.

Botany, by JOHN M. COULTER. Attention is called to the progress of botany and to the service it can render. While it began with merely classifying plants, an essential part now is the discovery of plants for use as food, for manufactures, for sources of important drugs, oils, resins, and other materials. An important step in the progress of botany has been the investigation of how plants live and work. It is really the application of physics and chemistry to plants, a study of the effects of air and soil. Other important steps in the progress of botany have been the study of environment, the problem of forestry, production, and inheritance. C. calls attention to the fact that progress has not been due to the study of practice but to fundamental research. He points out three important tendencies; (1) to attack problems that underlie some important practice, (2) an increasing realization of the fact that botanical problems are very complex, and (3) the growing recognition of the fact that structures are not fixed to their last detail.

Biology and Its Applications, by C. E. MCCLUNG. One outstanding lesson in our progress so far is that the scientific method provides the best means for determining conditions of existence and of providing the means for meeting them. To the final end of such understanding all divisions of science contribute, and it is not well to emphasize the service of one above the others. Because of the results obtained from biological study we live a longer life, a fuller life, and a more purposeful one. The average expectation of life has been raised since 1855 from fifty to fifty-eight years. It has been found feasible in the study of lower organisms by genetical means to alter the inherent character of living material so that it actually exhibits a longer individual life. By inducing natural phenomena to operations under given laws there has been removed much of the handicap which prevailed during periods when superstition largely took the place of understanding. One of the outstanding evidences of this is the better understanding of the causes of disease. The biologist is constantly confronted by the evidences of purpose in nature. However valuable the contribution of biology has been to material existence, the demonstration of an underlying plan forms the basis

for a philosophy of existence which is very definite and demonstrable. The evolutionary principle has entirely altered the philosophy of the world and if biology has rendered no other service to society than the establishment of such a philosophy of hope for development in the future, it would have served well.

Science, the Declaration, Democracy, by J. MCKEEN CATTELL. When the feudal system yielded to the industrial system, the wealth created by the applications of science made democracy feasible. History is controlled by economics by the applications of science. Science has led the way to true freedom of thought. He is no longer a scientific man who tries to force others to accept the discoveries that he makes, the laws that he finds, otherwise than by stating them and by using them. There can be no conflict between science and religion, between science and nationality, yet they are not separate spheres that do not touch. We still await greater production of wealth through the applications of science and its more equitable distribution for the further advance of democracy. Science and democracy advanced together but science has always led in providing wealth that supported large numbers of free and educated people.

America's Opportunity in Chemistry, by W. A. NOYES. It seems reasonable that America will some day take first rank in chemistry. What must she do to hold the position? To Liebig and to all those who have inherited something of his spirit the laboratory was not primarily a place for acquiring a knowledge of chemistry but a workshop where chemistry was made. This ideal of Liebig which trained students for independent thinking, N. believes was a dominant factor in placing Germany in the front rank in chemistry. A second factor was the close association between university laboratories and the factory. In America advancement appears to be coming through pure science research, not of the cut and dry type but that which learns the why and the how. This is being done, not only in the universities and in government bureaus, but in industrial research laboratories. Our great advances in industrial chemistry, however, rest on the work of the universities.

Engineering and the Nation, by D. S. KIMBALL. Industrial development has progressed along three well-defined lines, namely, labor-saving machinery, time-saving machinery, and machinery for transmitting intelligence. The great Corliss engine built in 1876 was considered a mammoth machine of epoch-making importance. It was rated at 1400 horsepower. Today a hydroelectric unit develops 70,000 horsepower and a steam turbine, 60,000 horsepower. The first locomotives weighed 3 or 4 tons, modern locomotives weigh 300 tons. Through the use of time-saving machinery man has been able to multiply his productive effort many fold. For transmitting intelligence the development of apparatus extends from the puffs of smoke made by the savage through the semaphore, the heliograph, the telegraph, and the telephone to the radio. Engineering has become a method of thinking by which men proceed to the solution of their problems through orderly reasoned methods based, as far as possible, upon known facts. G. W. S.

An Accurate Method for the Determination of Phosphorus Pentoxide as Magnesium Ammonium Phosphate. W. M. MCNABB. *J. Am. Chem. Soc.*, **49**, 891–6 (April, 1927).—The author claims to have settled at last that bugbear of the analytical chemist, the accurate routine determination of phosphorus pentoxide (and, of course, of magnesium). Schmidt's method of precipitating from a hot solution containing ammonium acetate was employed. An interesting fact soon noted was that the phosphorus is never completely precipitated from sodium phosphate solutions, whereas it is completely precipitated if the corresponding potassium salt is employed. This result is attributed by the author to the solvent action of the sodium chloride upon the precipitated magnesium ammonium phosphate. The method of Brookman was now employed, in dealing with the precipitate. It consists in dissolving it from the precipitating beaker and filter paper with 1:3 nitric acid, evaporating this solution to dryness in platinum, igniting and weighing. This method, while capable of yielding check results, is shown by the author to be uniformly low. A series of evaporations and ignitions were made on the acid solution and, by placing small watch glasses over the crucibles, definite amounts of sublimate could be collected which gave a yellow precipitate with ammonium molybdate solution. Another series was now carried out in which the solutions were made strongly ammoniacal before evaporation and ignition. In this series, no sublimate could be detected and the results obtained checked the theoretical within very close limits. The technic of the method is given in full. 18 analyses show results deviating by an average of from —0.03 per cent to +0.04 per cent from theoretical, while eleven acid evaporations show deviations from theoretical of from —1.39 per cent to +1.55 per cent. A. P. B.

Local Activities and Opportunities

Nebraska. The Nebraska Academy of Sciences met at the College of Agriculture campus of the University of Nebraska, Lincoln, May 5th, 6th, 7th. Papers upon the program of particular interest to chemists were the address of retiring president, J. A. Moss, and those of the following sectional program:

Program of Chemistry Section

C. S. HAMILTON, University of Nebraska.

Chairman

FRIDAY, 10.00 A.M., May 6, 1927

"The Chemical Examination for Morphine in Human Tissues," Victor E. Levine and Estelle A. Magiera, Dept. of Biological Chemistry and Nutrition, School of Medicine, Creighton University.

"Two Lecture Demonstrations for General Chemistry," Dr. E. R. Washburn, University of Nebraska.

"Formation of Potassium Iodo-di-cyanomercurate from Ferro Cyanides," Dr. Waldo Westwater, University of Nebraska.

"The Effect of the Method of Preparation of Copper on Its Reducing Activity," Mr. Ralph F. Nielsen, University of Nebraska.

"The Control and Attainment of Low Temperatures," Mr. S. A. Durban, University of Nebraska.

"Physical and Chemical Studies of Some Nebraska Clays," Mr. A. J. Rymes, University of Nebraska.

"Suggested Relationship between Vitamin B and Amino Acid Deficiency," Dr. C. W. Ackerson, University of Nebraska.

SATURDAY, 10.00 A.M., MAY 7, 1927

"Determination of Lead," Mr. J. A. Moss, Cotner College.

"Alkaline Oxidation of Sugars with Air," Mr. Edgar J. Boschult, University of Nebraska.

"Forecasting the Probable Success of a Student in College Chemistry," Mr. R. R. Ralston, University of Nebraska.

"New Organic Arsenicals," Miss Viola Jelinek, University of Nebraska.

"Chemistry Teaching in Nebraska," Mr. John S. Chambers, University of Nebraska.

The following papers in the biology section attracted many chemists.

"Sugar in Health and Disease," Victor E. Levine, Dept. of Biological Chemistry and Nutrition, School of Medicine, Creighton University.

"Chemical Reactions for Vitamin D," Victor E. Levine and George T. Lanahan, Dept. of Biological Chemistry and Nutrition, School of Medicine, Creighton University.

"Saving of Human Life by Oxygen," James F. McDonald, Prof. of Physiology, School of Medicine, Creighton University.

"Studies in Diabetes: The Effect of the Acetone Bodies on Blood Sugar," Victor E. Levine and Paul Shanguessy, Dept. of Biological Chemistry, School of Medicine, Creighton University.

O. S. C. T. A. The Executive Committee of the Ohio State Chemistry Teachers' Association held a meeting in Columbus on May 13th. At this meeting the Committee drew up a constitution and made arrangements for carrying out a definite yearly program. The constitution as drawn up by the Committee follows:

CONSTITUTION OF THE OHIO STATE CHEMISTRY TEACHERS' ASSOCIATION

I. *Name*—The name of this organization shall be the Ohio State Chemistry Teachers' Association.

II. *Purpose*—The purpose of this organization is to promote chemical education in the state of Ohio.

III. *Membership*—Any person subscribing to the JOURNAL OF CHEMICAL EDUCATION is eligible for membership.

IV. *Dues*—If the members will coöperate by sending to the Secretary of the organizations new subscriptions and renewals to the JOURNAL OF CHEMICAL EDUCATION, it will obviate the necessity of dues.

V. *Meetings*—There shall be not less than one meeting each year, ordinarily held in conjunction with the Ohio State Educational Conference at Columbus.

VI. *Officers*—Each year the chairman of the Executive Committee shall appoint a nominating committee of seven members, including the Senators of Chemical Education, who shall select an executive committee. The election of this committee shall be held at the annual meeting.

The Executive Committee shall appoint its own Chairman and Secretary.

The Executive Committee shall appoint the three Ohio members of the Senate of Chemical Education of the American Chemical Society.

Senators of Chemical Education shall be ex-officio members of the Executive Committee.

It shall be the function of the Executive Committee to transact all necessary business during the year and to present at the annual meeting a report of all important business transacted.

VII. *Amendments*—This constitution may be amended by a majority vote of members present at any meeting providing due notice in writing has been given previous to said meeting.

Martin V. McGill is chairman of this organization and R. P. Vickers was appointed Secretary-Treasurer for the coming year.

University of Florida. Professors T. R. Leigh, head of the Department of Chemistry, A. P. Black and V. T. Jackson will offer courses in chemistry during the summer session June 13th to August 5th. Prof. Black will act as Dean of Men.

Assistant Professor Robert C. Goodwin, will devote the summer to research at Harvard.

The annual banquet of Gamma Sigma Epsilon chemical fraternity, was held Thursday evening, May 12th. Prior to the banquet Mr. L. M. Drake, research chemist of Daytona, Florida, was initiated as an honorary member. Mr. Drake was the principal speaker at the banquet, taking for his subject "The Importance of Chemical Research in Industry."

The fourteenth meeting of the Florida Section, A. C. S., was held in the large lecture room of Science Hall on Saturday evening, May 21st. The paper of the evening, "Rare and Precious Metals," was given by Dr. V. T. Jackson, Associate Professor of Chemistry, of the University.

Yeast Makes Better Bread if Treated Right Chemically. Yeast is only a humble vegetable, but it has its likes and dislikes, and it will work better for the baker and make sweeter and lighter bread, if he treats it right and gives it the kinds of chemicals it likes, according to C. J. Patterson of Kansas City, who spoke before the recent meeting of the American Association of Cereal Chemists at Omaha. The yeast needs certain mineral salts in the right proportions to maintain good health, just as do other plants and animals, Mr. Patterson explained, and large-scale bakers are basing their batch formulas on scientific determinations of these chemical requirements instead of rule-of-thumb methods of old-fashioned baking.—*Science Service*

Recent Books

Textbook of Biological Chemistry. JAMES B. SUMNER, Ph.D., Cornell University. The Macmillan Co., New York City. First edition, 1927. xxv + 283 pp. 14 × 21.5 cm. $3.50.

The author states that the book is meant first and last for the elementary student, and for a book of this sort the ability to omit is fully as important as the ability to include. The topics included for discussion in an elementary text of two hundred and sixty-five pages are well chosen. The chapters are sufficiently complete in themselves to permit a choice in the order of presentation of the topics. Although it is claimed in the introduction that the aim of the biological chemist is to explain the chemical composition of plants and animals and the chemical structure of the compounds present, the text is written primarily from the animal point of view although the treatment is more general than in the conventional text on biochemistry advised largely for the student in medicine. The book closes with a very good chapter on the physical chemistry of protoplasm. The discussion of each of the well-chosen topics in this chapter is brief and concise and serves to emphasize the important applications of physical chemistry in biological problems.

C. O. APPLEMAN

History of the Sciences in Greco-Roman Antiquity. ARNOLD REYMOND, Professor of Philosophy at the University of Lausanne. Translated by Ruth Gheury De Bray. E. P. Dutton and Company, New York, 1927. x + 245 pp. 40 diagrams. 13 × 20 cm. $2.50.

Part I of this relatively small volume is an historical outline of the origins of the physical and biological sciences and mathematics. It begins with the work of the Egyptians and Chaldeans and traces the development through the Hellenic Period (650–300 B.C.), The Alexandrian Period (300 B.C. to the first century of the Christian Era) and the Greco-Roman Period (from the Christian Era to the Sixth Century, A.D.). Part II is an analysis of the "Principles and Methods." In this the development of science, attended by rational explanations and recognition of cause and effect relations, from an irrational belief in occultism and other forms of mysticism is interestingly told. There are chapters on The Mathematical Sciences, Astronomy, Mechanics and Physics, and the Chemical and Natural Sciences.

The reader will be pleased with the brevity of a book which at the same time carries such a wealth of historical facts, yet many times he will wish for a fuller interpretation. For example, the general reader will wonder how the practice of embalming the bodies of the dead in Egypt favored the practice of dissection and he will wish for some analysis of the circumstances which attended Herophilus' discovery of the nervous system. These important events are dismissed with a mere statement of the fact in one or two sentences. The book has numerous footnotes—some to original sources and others to secondary treatises. There is a bibliography of the principal publications relating to the science of the Egyptians, Chaldeans, Greeks, and Romans.

There is a definite recognition of the importance of the history of science, not only in the education of scientists but also in liberal training. It is valuable for its contribution to an understanding of the meaning of science and for its humanistic value. The translator has done a real service to lecturers and instructors in science by making available to them Pro-

fessor Reymond's interesting account of the earliest origins.

S. R. POWERS

Thermodynamics for Students of Chemistry. C. N. HINSHELWOOD, M.A., Fellow and Tutor of Trinity College, Oxford. E. P. Dutton and Company, New York, 1926. ii + 181 pp. + index. 11 diagrams. 12.5 × 18.5 cm. $1.80.

This book contains chapters on the following topics: Introductory, Applications of the First Law of Thermodynamics, The Second Law of Thermodynamics and Carnot's Theorem, The Gibbs-Helmholtz Equation, Maximum Work and Free Energy, Applications of the Isothermal Reversible Cycle, Entropy and Thermodynamic Function—Conditions of Equilibrium, The Foundations of the Phase Rule, The Problem of Chemical Combination, Entropy and Probability.

The author begins his preface: "This book has been developed from lectures in which I have done what I can to make the fundamental ideas of thermodynamics as clear as possible, and particularly to explain the methods by which the abstract general laws are brought to bear upon the actual problems of physics and chemistry." This object is certainly attained to a very considerable degree. The author succeeds in making clear many of the fundamental ideas of thermodynamics, ideas which are simple enough in themselves, but which ordinarily seem to give many students of thermodynamics a great deal of trouble. The book excels in this respect, that it devotes substantial attention to ideas which in many texts are frequently taken for granted or only briefly touched upon. The author also makes a special feature of pointing out in a most admirable way the intimate interconnections between the laws of thermodynamics and the kinetic theory.

The whole book is introductory in character, quite elementary. Very little quantitative information is presented, and no problems. It should prove very helpful when used in combination with some other more advanced text. The student would "get the general idea" of the subject from Hinshelwood's book and would then be ready to undertake the study of more detailed and more advanced treatments.

EDWARD MACK, JR.

Calculations of Quantitative Chemical Analysis. LEICESTER F. HAMILTON, Associate Professor of Analytical Chemistry, Massachusetts Institute of Technology and STEPHEN G. SIMPSON, Instructor in Analytical Chemistry, Massachusetts Institute of Technology. Second edition, 1927. McGraw-Hill Book Company, Inc., New York. xxiii + 239 pp. 2 figures. 14.5 × 21 cm. $2.25.

In this textbook of chemical calculations, there is the expressed purpose of satisfying that need in quantitative analysis which is described in the preface to the first edition. "Quantitative Analysis is a very practical branch of chemistry and a knowledge of the chemical principles involved and the acquirement of manipulative skill are of little practical value unless they are accompanied by an ability to compute and interpret results from analytical data, quickly and correctly." The authors realize that in a well-balanced course of instruction it is necessary to devote a portion of the time to stoichiometric principles and to the solution of practical and illustrative problems and yet there is the difficulty that too extensive instruction in chemical computations might require time which could be used more judiciously for the discussion of chemical principles. For this reason, the volume was prepared "in an attempt to attain the following objects: (1) to allow the instructor to devote more time in the class room to the chemistry of quantitative analysis; (2) to aid the student in grasping stoichiometric principles without extensive personal instruction; (3) to provide ample material for home assignments and quizzes; (4) to prepare the

way to more difficult problem work in physical chemistry and chemical engineering."

The second edition follows the same general arrangement as the first edition. Chapters and problems on electrometric titrations and on equilibrium constants have been inserted. The descriptive matter has been expanded in several instances, especially in the section devoted to precision measures, calibration of weights, electrolysis, and indicators. Many problems have been added and the miscellaneous problems have been rearranged and classified under descriptive headings. Answers have been given to a number of problems which represent the various types of calculations and many problems have been given without answers. This arrangement benefits student and instructor alike inasmuch as those problems with answers serve as a basis for self instruction and those without answers offer material for home assignments and quizzes. The text represents an advance in the teaching of quantitative analysis since it offers a clear discussion of type problems from which the student may be expected to grasp the principles of chemical calculations with less individual instruction.

VILLIERS W. MELOCHE

Quantitative Analysis. STEPHEN POPOFF. Ph.D. P. Blakiston's Son & Co., Philadelphia. Second edition, 1927. xix + 559 pp. 68 figures. 15×23 cm. $4.00.

This edition has been considerably enlarged by the addition of twelve new chapters and many of the methods of procedure have been changed to give greater precision. The book is divided into four parts. Part I, Laboratory Directions, covering 258 pages, contains a discussion of the balance, apparatus, and calibrations and methods for analytical procedures, together with an explanation of the theory involved.

Part II, Calculations, covering 50 pages, takes up Errors and Computations and the methods of solving problems ordinarily met with in analytical work. Problems to be worked by the student are included.

Part III, The Theory of Analytical Chemistry, 177 pages, gives in a simple manner the fundamentals of physical chemistry which are essential for a proper understanding of the methods involved in analytical procedure.

In Part IV, Special Topics, 87 pages, electrometric titrations, colorimetric methods, and iron and steel analysis are taken up. Part V contains various tables necessary in analytical work.

Each chapter is marked with a subscript indicating the type of student for which it is intended. Of a total of 69 chapters, 36 are intended for beginning students, 38 for the more advanced and 27 for the graduate student. Only three chapters, those mentioned in Part IV, are for graduate students exclusively. In addition to the section on calculations, questions and problems, together with references, are given at the end of each chapter.

Such subjects as the analysis of fuels, water, oils, and assaying are not treated. While certain procedures must of necessity be omitted and the number of optional methods limited, the book as a whole is very well written and the subject matter is presented in a clear and concise manner. Those who have used the first edition will be pleased with the improved physical appearance of the book as well as the changes and additions in subject matter.

D. C. LICHTENWALNER

Physico-Chemical Geology. R. H. RASTALL. Longmans, Green & Co., New York City, 1927. vii + 248 pp. 13.5 × 21.5 cm. $6.00.

As its name implies, this book is an attempt to show how the application of the principles of physical chemistry to the problems of geology has aided in correlating and organizing an immense mass of data. The attempt is a success. Dr. Rastall is to be congratulated on the excellent fashion in which he has handled the

subject. It is to be hoped that others will write on the practical applications of physical chemistry in a similar manner.

Physico-Chemical Geology presupposes a knowledge of the fundamentals of geology and mineralogy, but none of the phase rule. In consequence the first two chapters deal with heterogeneous equilibrium in general, thermal analysis and a detailed discussion of one-, two-, and three-component systems. These chapters are very well done, but it seems that it might have been more profitable to presuppose a knowledge of these matters and devote the space saved to a more detailed discussion of the various problems considered.

The chapter on Isomorphism and Solid Solution is very fine and abounds in geological illustrations. The same is true of the chapters on Polymorphism, The Igneous Rocks, Mineral Formation, Metamorphism, The Salt Deposits, Ore Deposits, and Refractories and Abrasives.

One could wish for a much more extended discussion of Colloids in Geology. The Physical Chemistry of Rock Weathering would be improved by stressing mass action effects to a greater extent.

This book is non-mathematical and full of interest even for one not well up in geology and mineralogy. It reads easily and incites a desire to know more. The chief criticism to be made is that Dr. Rastall did not keep on with his narrative.

MALCOLM M. HARING

Old Chemistries. EDGAR F. SMITH, University of Pennsylvania. McGraw-Hill Book Company, Inc., New York, 1927. x + 89 pp. 32 illustrations. 11.8 × 17.5 cm. $2.50.

The main purpose of this book, according to the author, is to bring to the attention of chemists, in particular to American chemists, "a story of chemical books used for instructional purposes in the infancy of our country." The author, as is well known, is the leading historian of chemistry in America; and from his large and splendid collection of old books he has selected those volumes which best illustrate the fact that "the American Fathers of Chemistry had an interest in their science equal to that exhibited by any of its modern disciples." From a perusal of "Old Chemistries" we learn what foreign influences prevailed in the teaching of chemistry to our ancestors; also the part early American chemistry teachers had in the writing of textbooks. The books selected cover a period of about three hundred years, beginning in the middle of the sixteenth century. The illustrations are excellent, and they include portraits of such eminent men as Benjamin Rush, Lavoisier, Joseph Black, Robert Hare, and Benjamin Silliman. The volume includes a portrait of Jane Marcet who wrote a most delightful text, entitled "Conversations on Chemistry." This book first appeared in London about 1805.

In this very interesting volume, Dr. Smith clearly exhibits his thorough knowledge of the history of the science he loves so well, and in his story shows us that—"through these manifold, twinkling, sparkling pages something of the past beckons us, whispers us, delights us."

"Old Chemistries" would be a valuable addition to any library, and should be of special interest to educators and chemists who want authoritative information concerning the history of one of the greatest sciences.

WILLIAM FOSTER

The philosopher should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; and in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of Nature.—FARADAY

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